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PROJECT RULISON

DEFINITION PLAN

December 9, 1968

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I. INTRODUCTION

A. GENERAL

Project Rulison, located in Garfield County, Colorado (Figure I.1), has been proposed as a joint Industry Government-sponsored nuclear gas stimulation experiment in the Plowshare program. The project, proposed by Austral Oil Company Incorporated (Austral) of Houston, Texas, and CER Geonuclear Corporation (CER) of Las Vegas, Nevada has been designed as a demonstration of the commercial feasibility of stimulating a natural gas reservoir using a nuclear explosive.

The gas bearing Mesaverde Formation appears to be productive under 60,000 acres at Rulison Field and contains an estimated 8 trillion standard cubic feet of gas in place. The reservoir is not commercially productive using conventional completion techniques. This is the first project proposed in a gas reservoir that could support commercial nuclear exploitation.

Successful nuclear stimulation at Rulison Field will not only add to the gas reserves of the country but, since over 50 percent of the acreage is on Federal Government leases, the Government could derive significant royalties from the production of gas from this field.

B. BACKGROUND

Austral became interested in the use of nuclear explosions to stimulate gas reservoirs in early 1965, and began evaluating properties which might be amenable to this approach. It found that the Mesaverde Formation in the Rulison Field of west central Colorado appeared to be suitable. Drilling and testing information indicated that this formation seemed to have adequate gas in place but had so little permeability that conventional production stimulation methods appeared impractical and uneconomical.

Austral initially acquired approximately 20,000 acres from other operators, and options on an additional 20,000 acres. At Austral's request, CER conducted a surface site tour in the early winter of 1965-66 which further indicated that the site had the potential for nuclear stimulation and that such stimulation could be done safely due to the remoteness and depth of the formation in which the nuclear explosive would be detonated. The depth is significant because it essentially reduces to zero the possibility of any dynamic radioactivity release.

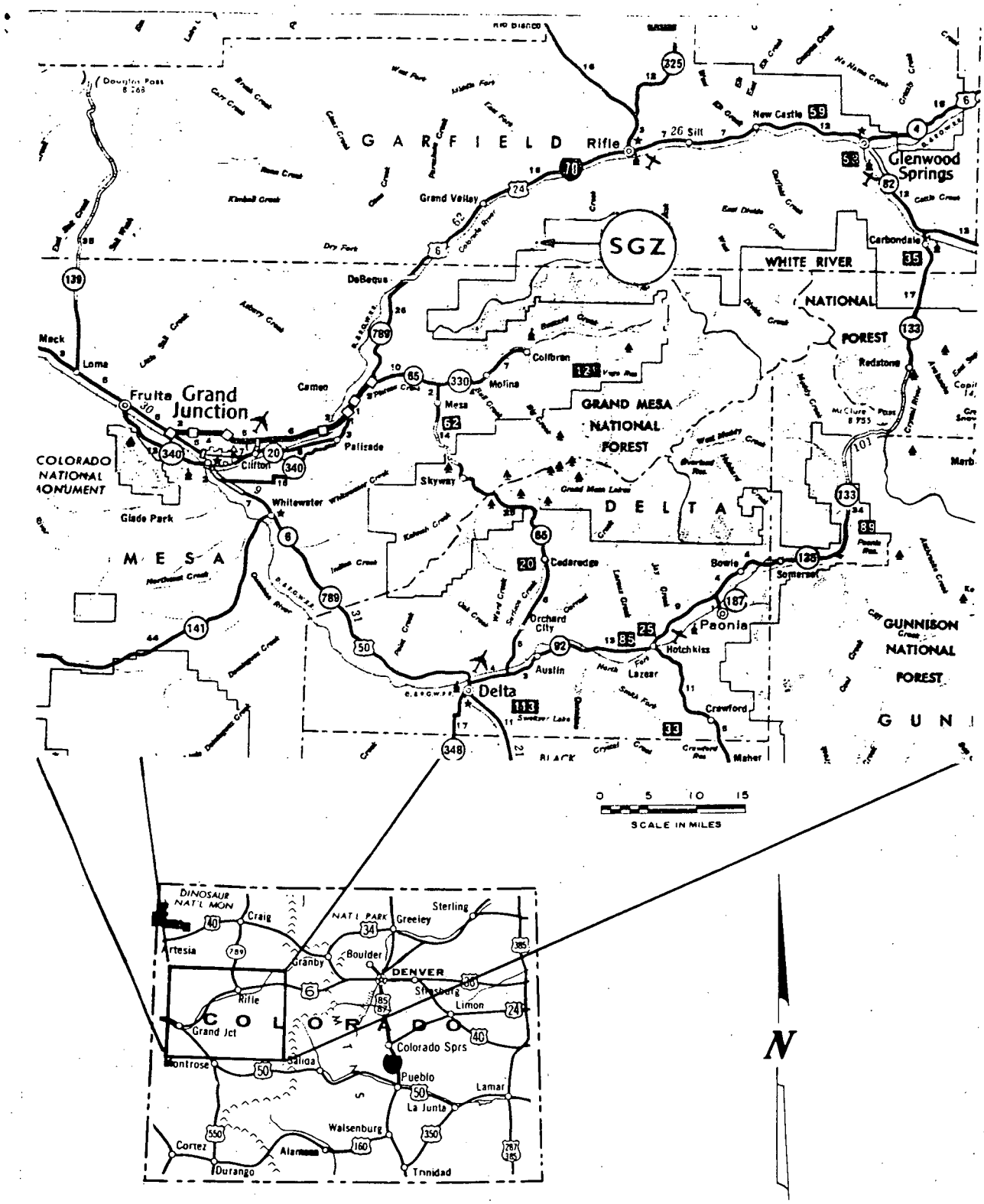


Figure I.1
Road Map of Northwest Colorado

Work started immediately on the preparation of a detailed nuclear stimulation feasibility study, additional leases were obtained, and two test wells drilled. Upon completion of these wells in the spring of 1966, Austral/CER carried out an extensive well testing program to verify earlier calculations of gas in place and more accurately define the producing characteristics of the Mesaverde reservoir.

In July of 1966, Austral/CER submitted a formal letter of intent to the Atomic Energy Commission (AEC) along with a detailed report, entitled "The Project Rulison Feasibility Study."[1]

In September 1966, Austral met with the United States Geological Survey (USGS) to discuss a unit agreement for the Rulison Field, which would provide for development through the use of nuclear stimulation.

In December of 1966, Austral/CER made a formal presentation of Project Rulison to the Atomic Energy Commission. On February 17, 1967, Austral reiterated its complete commitment to this project to the Joint Committee on Atomic Energy.

In the spring and summer of 1967, Austral/CER and Lawrence Radiation Laboratory (LRL) personnel discussed the criteria for the actual site selection, inspected the proposed site area, and evolved preliminary drilling specifications for the project's exploratory well, R-EX (Hayward 25-95).

On October 4, 1967, Austral and the USGS signed a unique nuclear stimulation unit agreement which recognized the experimental nature of the project and the time frames necessary to complete the experiment. The unit as approved, encompasses 50,821.41 acres.

In late summer of 1967, Austral built a $3\frac{1}{4}$ mile road from Morrisania Mesa to the project site. The contract for drilling the R-EX was signed on November 1, 1967, and drilling operations started on November 9, 1967. This well was completed on May 6, 1968.

The development of a Technical Plan was aided by discussions at a number of meetings between Austral/CER, LRL, and U.S. Bureau of Mines (BuMines) personnel. In April 1968, the supporting laboratory assigned to Project Rulison was changed from LRL to Los Alamos Scientific Laboratory (LASL) by direction of the AEC Division of Peaceful Nuclear Explosives (DPNE). This document now incorporates the changes which were necessary to implement LASL's concept for nuclear fielding and detonation.

Drafts of the Technical Plan have been reviewed by the USGS, BuMines, LASL, and the AEC.

The concept for the development of the Rulison "Project Definition" phase was first presented on May 7, 1968, at a U S AEC Nevada Operations Office (NVOO)/CER meeting. This concept was that a Project Definition document, prepared by industry with help and guidance from NVOO, BuMines, and LASL, was to contain the experimental, executional, operational, and managerial plans necessary to fully define the scope of the project.

On May 10, 1968, Austral/CER representatives met with representatives of NVOO, LASL, Air Resources Laboratory, a Division of Environmental Science Services Administration in Las Vegas (ARL/LV), United States Public Health Service (USPHS), and BuMines, and agreed upon the overall plans for the development of this Project Definition document.

A second meeting was held in Grand Junction, Colorado, on June 11-12, 1968, to further the Project Definition. On July 2, 1968, a proposed Project Definition outline and schedule were presented to NVOO.

The total Project Definition package serves as the basis for the Industry/Government Contract Negotiations.

C. OBJECTIVES

The objective of the Project Rulison is to determine the potential of nuclear stimulation for the commercial development of the Rulison Field. Since the Rulison area, with its moderately deep, thick, lenticular low permeability sequences of the Mesaverde, Wasatch, Fort Union, Lewis and Erickson Formations, is typical of many gas fields, the information obtained from the project would have an important bearing on the commercial possibilities of nuclear stimulation of other areas. Specifically, information is needed in regard to:

1. Technical Information

   a. Pre- and post-shot gas production characteristics from the site area, such as:

      1) The pre- and post-shot net production interval in the nuclear-stimulated portion of the reservoir.

2) The important post-shot environment characteristics in gas reservoir stimulation, such as effective height and volume of the chimney and the effective fracture zone radius as determined by production testing.

3) The pre- and post-shot flow capacity.

4) The changes (if any) of the effective flow capacity of the nuclear-fracture zone with time and decreasing reservoir pressure.

b. The degree and species of radioactive contamination present in the gas from the nuclear chimney at drillback and the amount of residual activity in the produced gas as a function of time, rate, and cumulative production.

c. Seismic effects on cultural features to provide information on appropriate yields for future field development.

2. Economic Information

The costs incurred in the operational aspects of the experiment, such as construction, fielding, and support, together with the technical data, will allow some assessment of the potential for future commercial development of the Rulison Field. In this context, it is planned to reduce costs wherever practical and specifically to operate with minimal personnel on-site and be consistent with technical objectives and safety.

D. SITE DATA

1. Description of Area

The Rulison Field consists of approximately 60,000 acres in the south-central portion of Garfield County, partly overlapping into the northeast portion of Mesa County. The boundary of the approved Federal Unit (see Figure I.2) lies generally south of the Colorado River and extends from an elevation of about 5,200 ft near the river up the slopes of Battlement Mesa to an elevation of over 10,000 ft. The proposed Surface Ground Zero (SGZ) for the Rulison experiment is in Section 25, Township 7 South, Range 95 West (Sec. 25, T7S, R95W) adjacent to the R-EX well shown in Figure I.2 as Hayward 25-95. This site, in the southern part of the field, is on the upper reaches of Battlement Creek at an elevation of about 8,200 ft. The valley is open

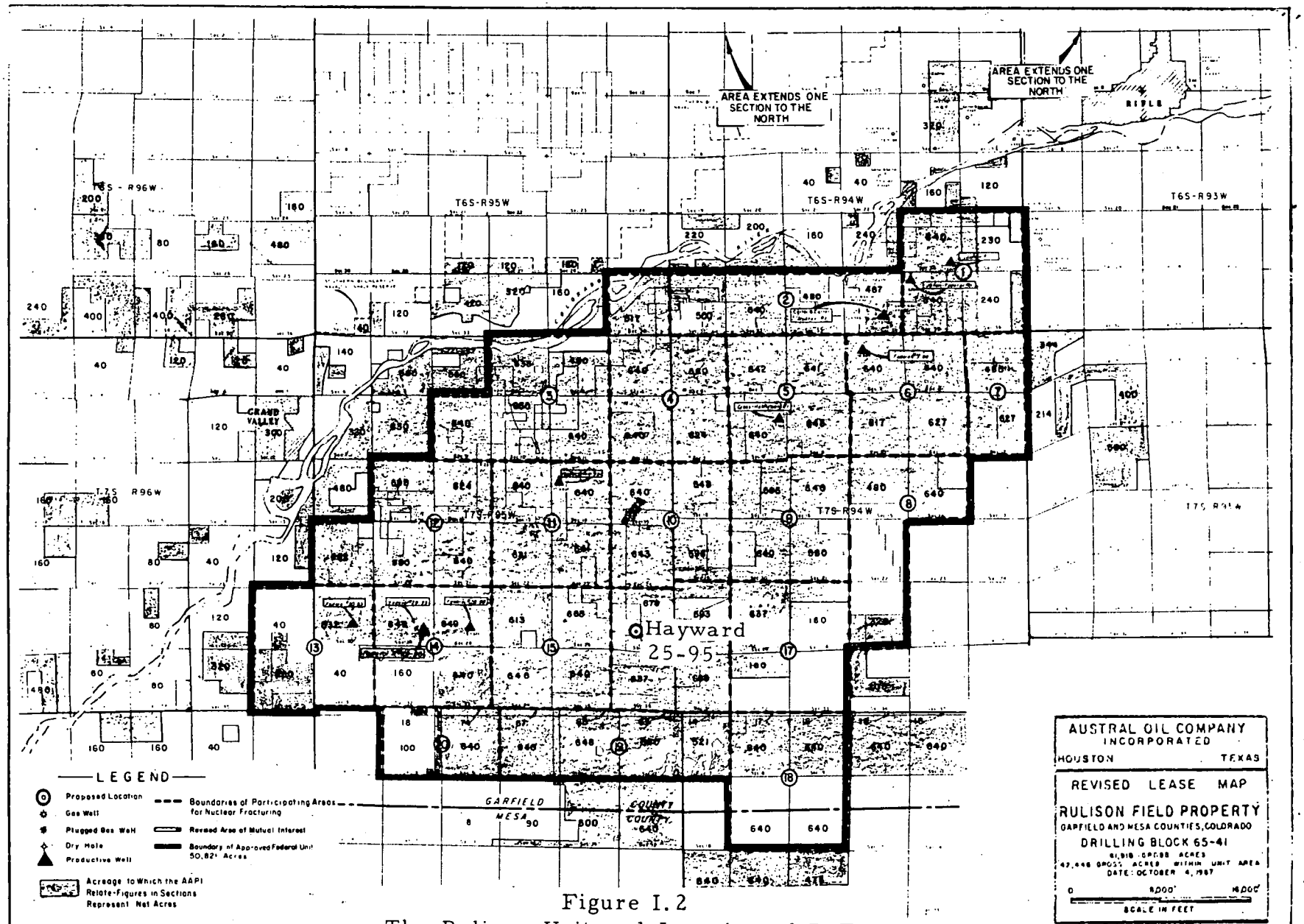


Figure I.2
The Rulison Unit and Location of R-EX
(Hayward No. 25-95)

to the north-northwest and is bound on the other three sides by steep slopes rising to above 9,600 ft. SGZ is adequately served by a 16-ft wide graveled road that connects with the county-maintained road system in Sec. 10, T7S, R95W.

The nearest city with commercial airline connections is Grand Junction, population about 22,000, approximately 40 miles to the southwest (Figure I.1). The nearest city with substantial industry is Rifle, population about 2,200, approximately 12 miles to the northeast. The nearest town, Grand Valley, has a population of around 245 and lies about 6 miles northwest of SGZ.

The area is served by the Denver, Rio Grande and Western Railroad with sidings for project use, if required, at both Grand Valley and Rifle. The area is also served by a two-lane highway, U.S. 6-24. A local road system with two 10-ton capacity bridges, one near Grand Valley, the other at the settlement of Rulison, furnish access across the Colorado River. Approximate road travel distances are shown in Table I.1

TABLE I.1

Approximate Road Travel Distances in Statute Miles:

Grand Junction to Rifle	66	
Grand Junction to Grand Valley	49	
Grand Valley to SGZ	7.5	(~6.5 gravel)
Rifle to SGZ		
via Rulison Bridge	21	(12 gravel)
via Grand Valley Bridge	25	(~6.5 gravel)

The population of the immediate Rulison area is confined principally to the valleys of the Colorado River, Plateau Creek, a tributary, and adjacent mesa-lands. Preliminary data, based on a count of dwellings shown on large-scale maps and assuming a density of 4 persons per household, indicates that about 220 persons live between 3.5 and 5 miles from SGZ, and about 1,500 additional persons live between 5 and 10 miles from SGZ. No permanent habitation exists

closer to SGZ than 3.5 miles.

The economic base to the immediate area is provided by raising of livestock and cultivation of orchards and livestock feed, the Union Carbide Plant at Rifle, The Oil Shale Corporation plant in Parachute Creek, and the railroad.

2. Geologic

Geological background investigations of the Rulison area [1-6] show a uniformly simple structural picture of the project area. The Rulison structure is part of the Piceance Creek Basin, with its relative position in the Basin shown in Figure I.3. The field is on the southwest limb of the Basin structure (see Figure I.4). Upper Cretaceous beds in this area dip towards the northeast at the rate of approximately 150 ft per mile and Tertiary age beds lie relatively flat.

Details of the Battlement Mesa geology were discussed with representatives of the USGS who contributed maps and reports on the area [7][8]. In addition, a surface geological study of a few mile area surrounding the site was made by Austral/CER, and LRL geologists.

Aerial photo coverage (scale about 1:24,000) was flown by Austral on the Battlement Mesa area to supplement the available smaller scale aerial photographs (GS-VAAL, 1960). Stereo pairs from Austral's coverage were studied, and linears occurring within a mile of the proposed location were plotted on overlays and transferred to a 1:24,000 Rulison 7 - 1/2° Quadrangle topographic map (Figure I.5). Much of the bedrock in the stream valley is covered by deposits mapped by Yeend [7] as Quaternary slides, mud flows, and fan gravels, (Qsl and Qgmf (Figure I.6). Excellent continuous exposures of bedrock, mapped by Donnell [8] as the Parachute Creek (Tgp) and Garden Gulch (Tgg), occur in the walls of Battlement Creek Valley. These continuously exposed beds were walked, and particular attention was given to areas where linears intersected the outcrops. No displacements or traces of faulting were found. The continuous beds traced in this study are traced in heavy lines on Figure I.5.

Many of the linears were found to be related to the well-developed joint sets in the area. Other linears were associated with slide margins, and topographically and geologically controlled vegetation.

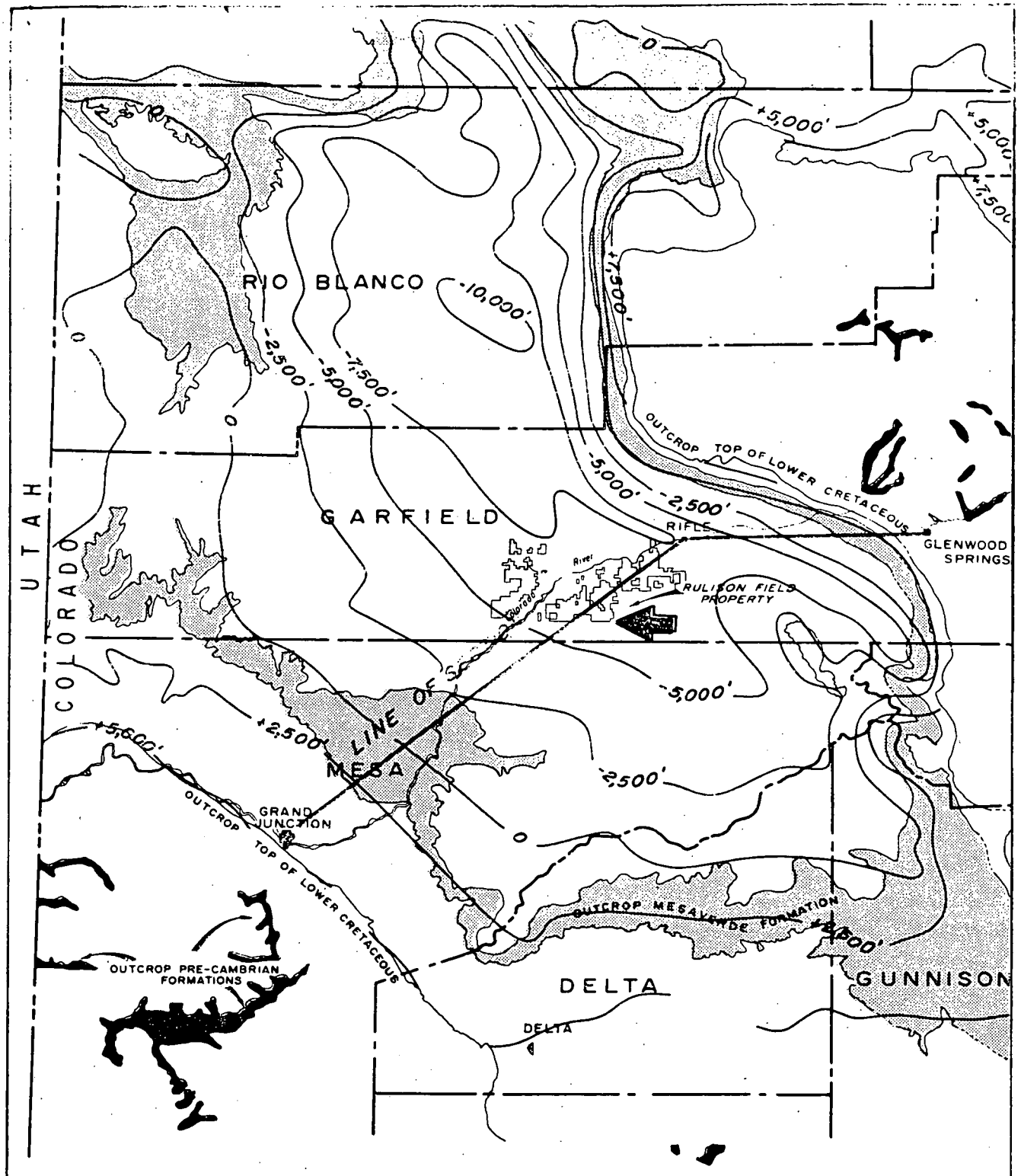


Figure I.3
Piceance Creek Basin-Regional Map and Structural Interpretation
(Contoured on Top of Lower Cretaceous and Showing
the Posistion of Rulison Field Properties Relative to
Surface Exposures of Mesaverde and Precambrian Formations)

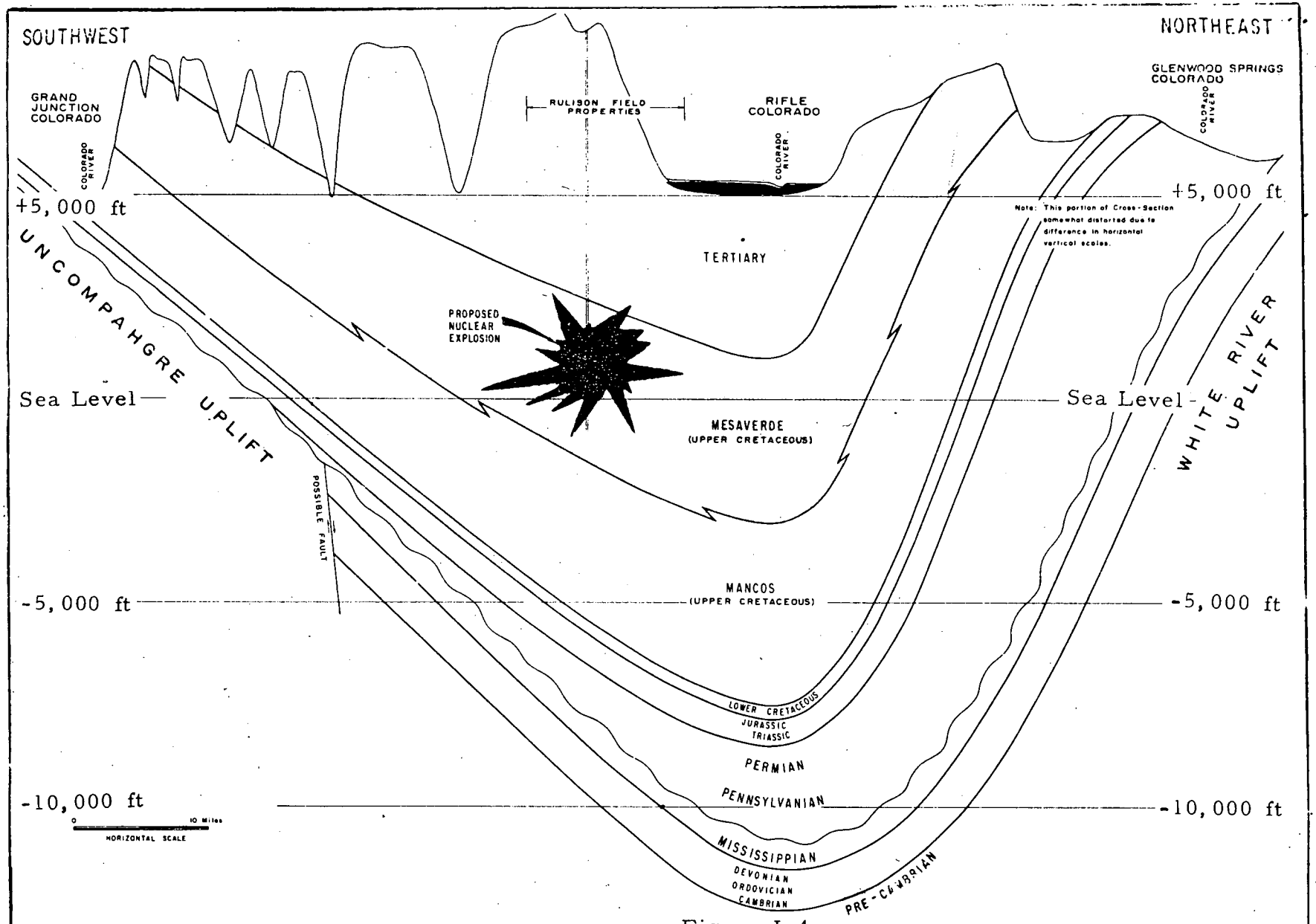


Figure I.4

Piceance Creek Basin - Northeast-Southwest Cross Section

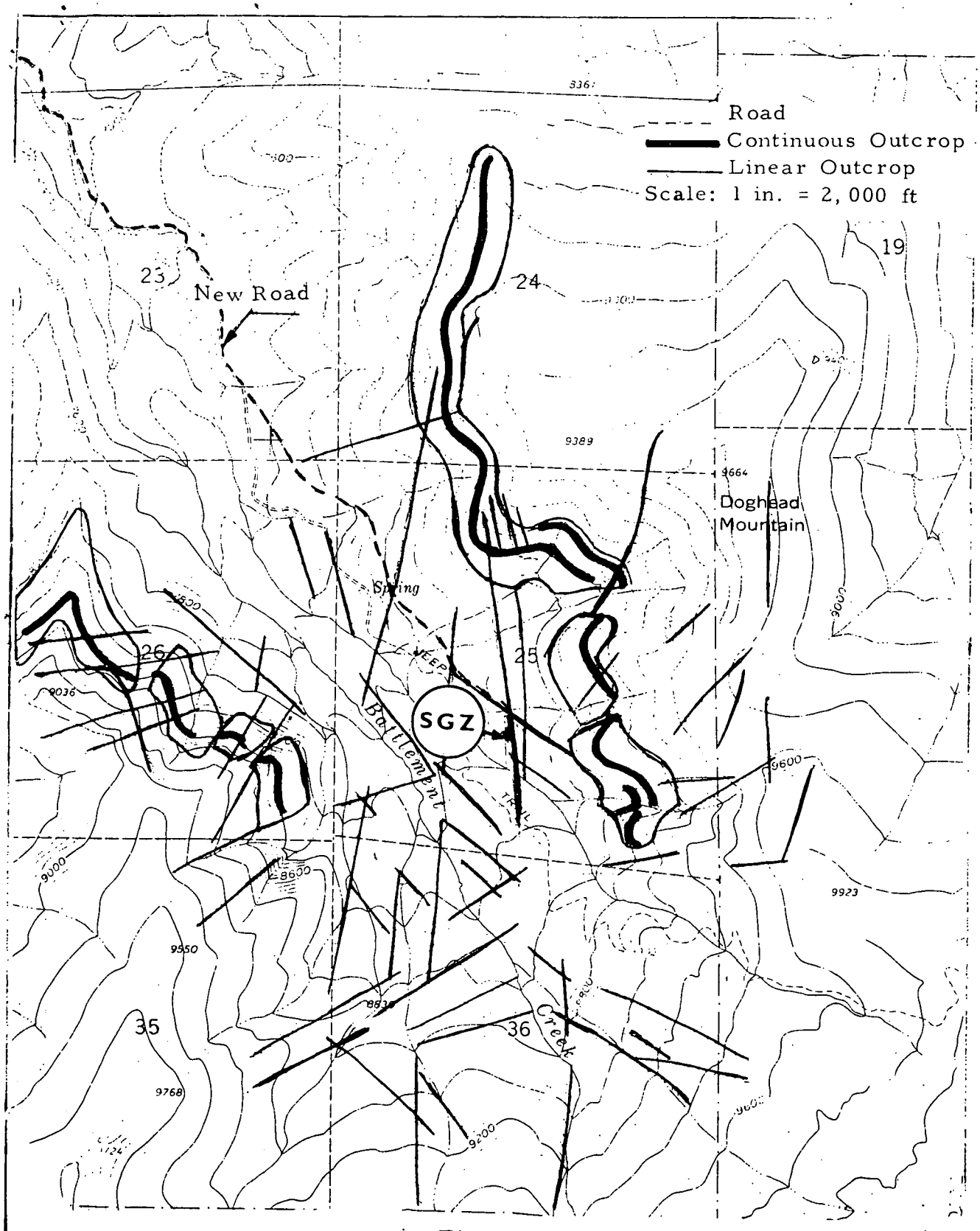


Figure I.5
Geological Map of Rulison Area

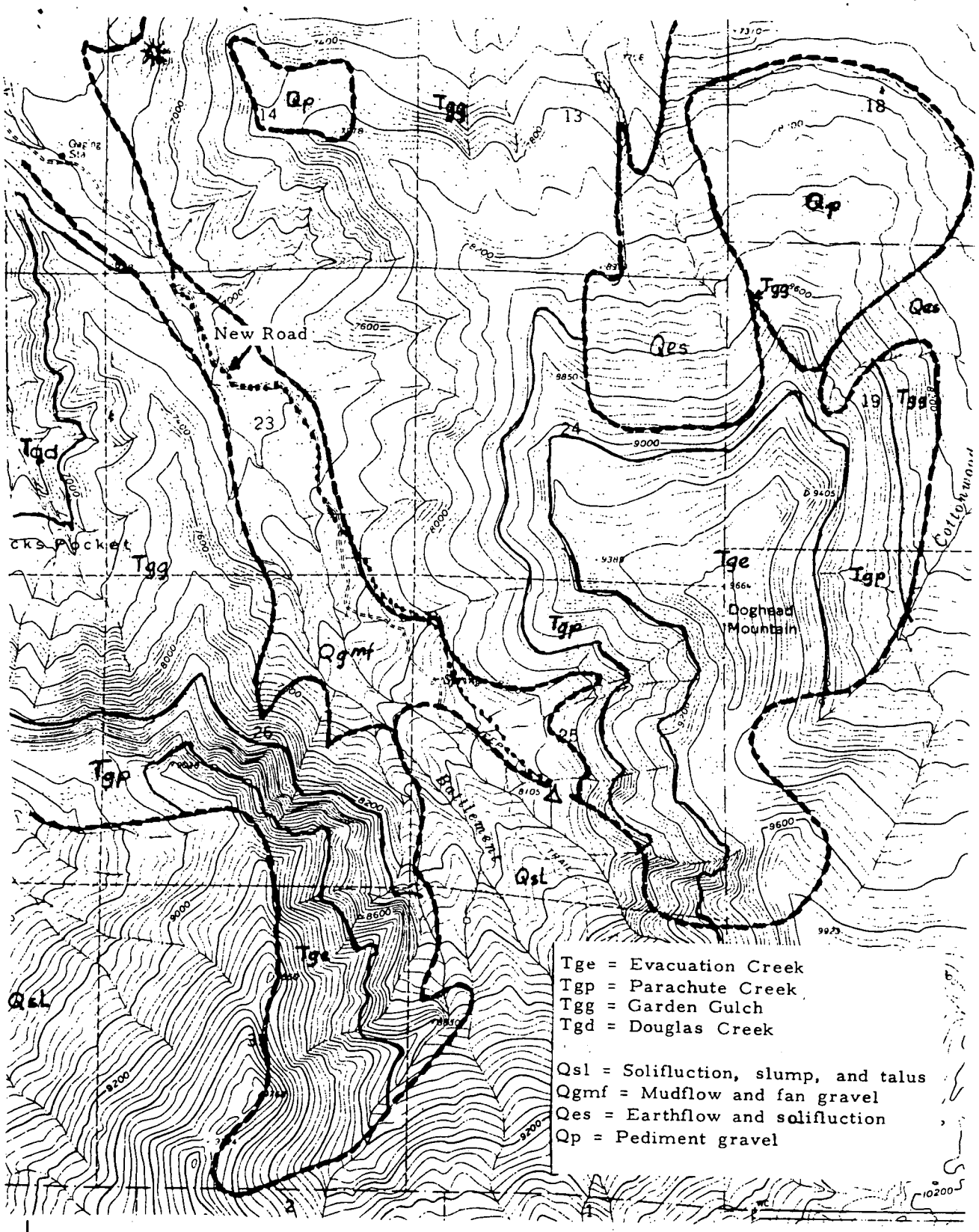


Figure I.6
Surface Geological Map, Project Rulison Area

The dips and elevation of a bedrock marker near the base of the Parachute Creek oil shale member of the Green River Formation were used to construct a "phantom" structural map throughout the project area (Figure I. 7). No discontinuity was noted across the Battlement Creek Valley. The bedrock in the valley floor is covered by Quaternary slides, fan and mud flow material.

3. Stratigraphic

Rocks ranging in age from recent alluvial fill in the valleys to Precambrian "basement" are present in the Rulison area. The sequence of rocks present and their relation to the general stratigraphy of the Piceance Creek Basin are shown in Figure I. 8.

The "bedrock" at the Project Rulison site is the lower Green River Formation. The base of the Green River occurs at a subsurface depth of approximately 1, 700 ft in the R-EX well. Relatively impermeable Wasatch and Fort Union shales and siltstones were encountered below the Green River in the interval from approximately 1, 700 ft to 6, 134 ft in R-EX. The basal Tertiary Ohio Creek Formation occurs between the Fort Union and the Mesaverde, encountered at 6, 188 ft.

The Mesaverde Formation in the Rulison Field area was deposited in the near shore environment that included marine, floodplain and coastal swamp conditions. This depositional setting resulted in lenticular sandstones that, from available data, have limited areal extent. The lenticularity of the Mesaverde sandstone reservoirs is the cause of gas entrapment in the Rulison Field.

An evaluation has been made of the continuity and geometry of the Mesaverde Formation outcrops in DeBeque Canyon. The results of this study are summarized in the "Project Rulison Feasibility Study."(1) Some of the interesting stratigraphic features noted in the study were the average thickness to length ratio of 1:20 for the sandstone layers and the common occurrence of coal layers in the bottom half of the formation.

The general character of the Mesaverde Formation in Rulison Field, as shown by electrical logs, is illustrated by Figure I. 9. Logs run in R-EX indicated an average net pay of 375 ft for the depth penetrated. Comparing this section with others in the Rulison Field (specifically those in Sections 28, 29 and 30 to the west) one would anticipate that greater penetration would reveal a potential net pay equivalent to the 500 ft average found in the developed portion of the field.

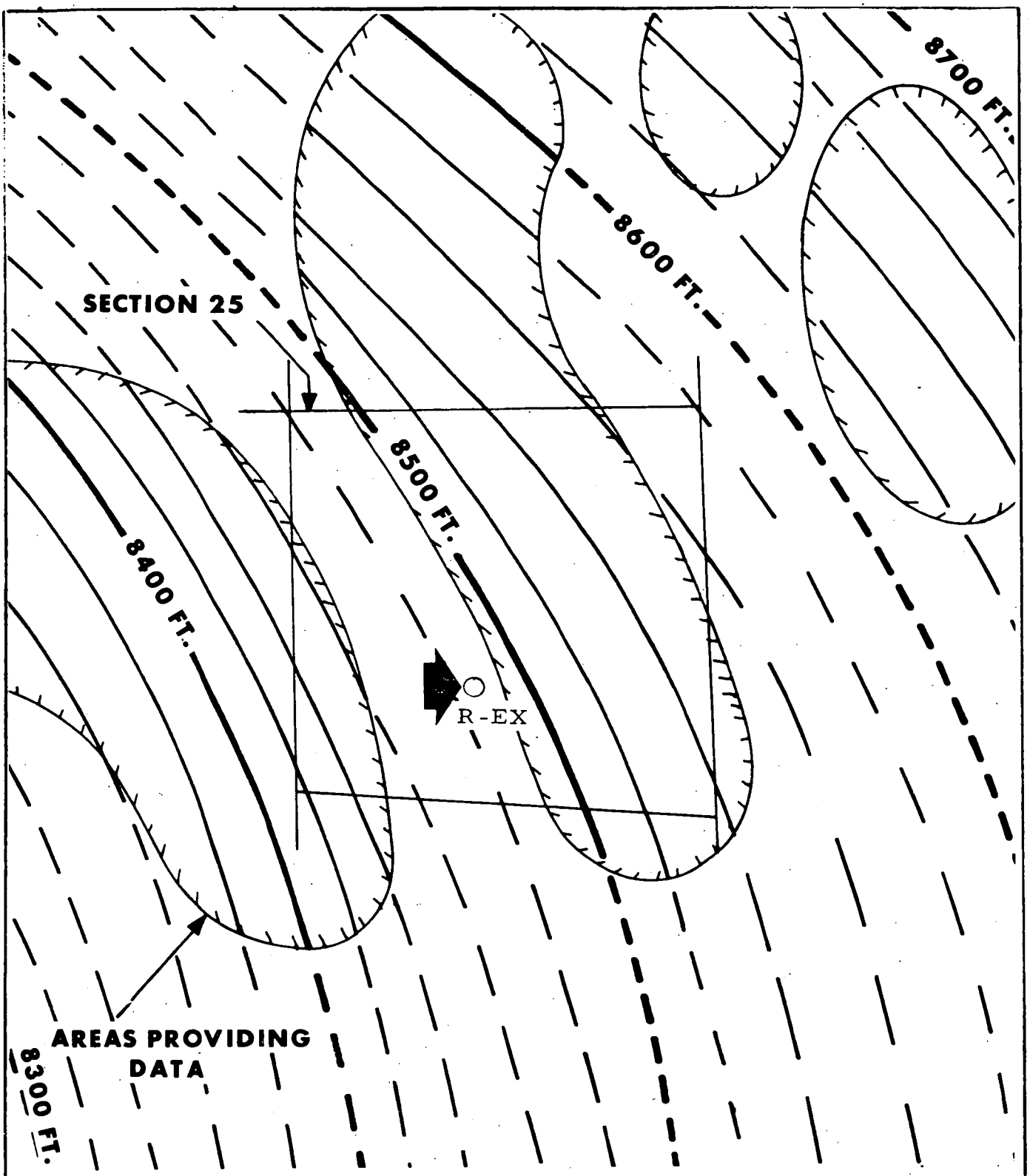


Figure I.7
Projected Structural Map
Green River Marker Horizon,
Scale: 1 in. = 2,000 ft

SYSTEM AND PERIOD		"FORMATIONS"	GENERAL LITHOLOGY	APPROX. THICKNESS
Quaternary		"Recent"	Low terrace, floodplane, and alluvial deposits	100'
		"Pleistocene"	Terrace and fan sand and gravel, pediment gravel, colluvium, mudflow, and solifluction deposits	200'
Tertiary		(?)	Basalt flows underlain by variegated claystones and gravel	1,000'
		Green River	Oil shales, marlstones, and sandstones (dark color)	2,100'
		Wasatch	Bright colored clays and shale with minor sandstone	5,000'
		Fort Union	Brown-gray shale and coal	1,000'
		Ohio Creek	Sandstone and conglomerate	50'
Cretaceous	Upper Mesaverde	Lewis-Lance Equiv.	Shale - sandstone	2,500'
		Williams Fork	Shale	
		Isle	Shale - sandstone	
	Lower	Mancos	Gray shale	1,700'
		Naturita	Shale - sandstone	600'
		Dakota Cedar Mt.	Sandstone	200'
Jurassic		Morrison	Variegated shale and sandstone with interbedded tuff and ash	800'
Triassic		State Bridge	Red arkosic sandstone	600'
		Schoolhouse	Sandstone	60'
Permian		Minturn	Continental red beds interbedded with white Weber type sandstone	1,000'
Pennsylvania		Maroon	Buff-red sandstone	
		Eagle Valley	Evaporites (chiefly anhydrite)	2,800'
		Belden	Gray to black shale with basal conglomerate	
Cambrian through Mississippian		Madison, etc.	Limestone, dolomite and quartzite	~700'
Pre-Cambrian			"Basement" metamorphics and plutonics	

Figure I.8
Rulison Area Stratigraphy

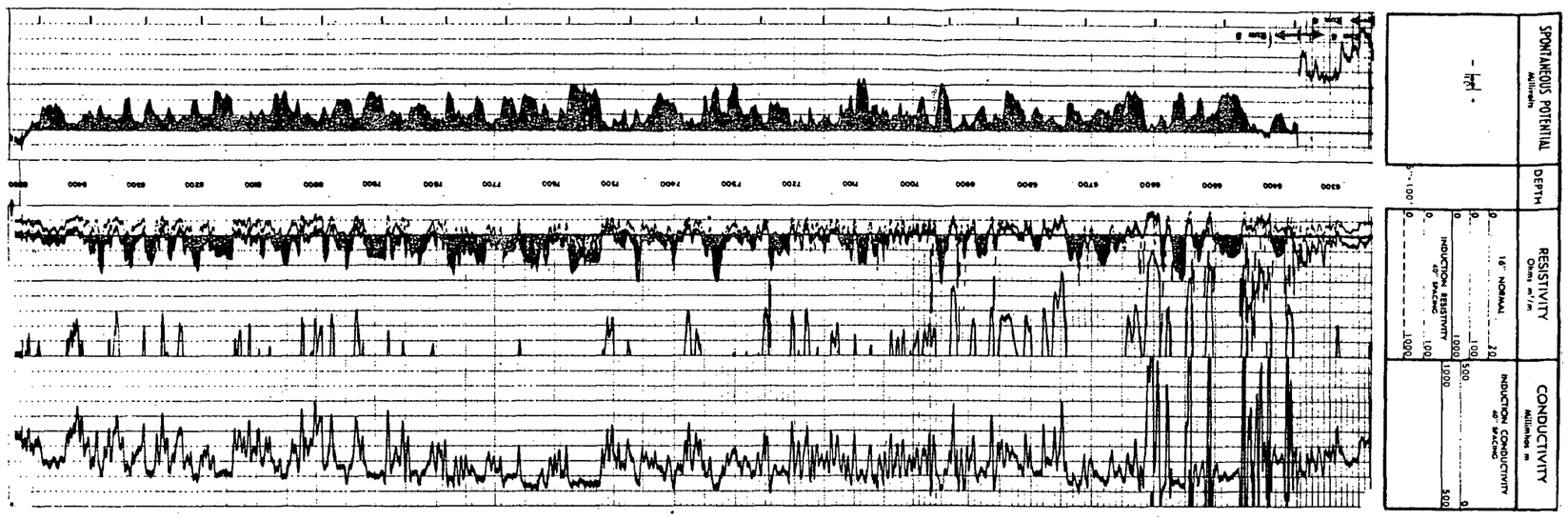


Figure I.9
Electrical Logs Showing the
Mesaverde Formation in Rulison Field

The productivity of the reservoir in the project area is low. The specific reservoir characterization at the site is being determined by production testing in R-EX.

The Mesaverde Formation in Rulison Field ranges in thickness from 2,500 to 4,000 ft. It is underlain by the Mancos Formation which is a sequence of Lower Cretaceous shales and sandstones having a thickness of approximately 2,500 ft.

4. Reservoir Characteristics

The average Mesaverde Formation characteristics obtained from an analysis of logs, core, and production data from existing wells in the field are summarized in Table I.2. For comparison, these same average characteristics from the initial evaluation of data from R-EX are given in Table I.3. A more detailed discussion of reservoir conditions at Rulison Field can be found in the "Project Rulison Feasibility Study."(1)

TABLE I.2

AVERAGE RESERVOIR PROPERTIES
RULISON FIELD, COLORADO

Sandstone Lens Property	Average Value
Porosity	9.7%
Permeability	0.5 md
Saturation	
Water	45%
Gas	~ 54%
Oil	< 1%
Basis for Volumetric Calculations	
Net Sand	500 ft
Base Pressure	15.025 psia
Base Temperature	60° F
Initial Gas Deviation Factor (Z)	0.88
Gas-in-Place	90 - 125 Billion scf/640 acres

TABLE I.3

AVERAGE RESERVOIR PROPERTIES
R-EX (HAYWARD 25-95) DATA

Sandstone Lens Property	Average Values	
	Core	Log
Porosity	8.7%	7.8%
Permeability	0.11 md	--
Saturation		
Water	44%	38 - 55%
Gas	~ 55%	45 - 62%
Oil	< 1%	
Reservoir Temperature at 8,400 ft subsurface	215 ± 4°F	
Estimated Net Sand in Gross Interval from 7,302 - 8,464 ft	375 ft	
Estimated Gas in Place	110.6 Billion scf/640 average acres	

5. Hydrologic

The Colorado River and its larger tributaries in this area flow on alluvial deposits. Limited coring by the USGS Ground Water Branch shows that the suballuvial floors of the valleys are approximately 80 to 100 ft below the flowing stream levels.

Most of the precipitation in this area is carried into the Colorado River by small streams or underflows in the alluvial fill or terraces. A few springs are present where the underflow in the alluvium is deflected to the surface by relatively impermeable bedrock.

The residents of Morrisania Mesa and the town of Grand Valley obtain water for both domestic and agricultural purposes from shallow wells drilled into the alluvium or from cisterns and ponds fed by the creeks or springs, some of which originate in the Battlement Creek drainage area.

There are some sandy zones in the lower Green River Formation which appear to be water bearing. In the immediate site area these zones occur at elevations greater than 6,600 ft above sea level and are remote from permanent habitation.

In general, the Wasatch Formation underlying the alluvial deposits is relatively impermeable and is not used as a ground water source. There are some sandy zones near the top and in the middle of the Wasatch, but because of the general flat-lying nature of the beds and the lack of permeability found in the R-EX well, it is felt that very little active ground water movement occurs.

The Ohio Creek Formation lying between the Wasatch and the Mesaverde Formation is water productive in some areas of Rulison Field, but was impermeable at the R-EX well and produced no water when tested by the USGS.

Some water production was encountered in an upper Mesaverde sandstone while air drilling R-EX. Since the Mesaverde sands are quite lenticular and since similar water production has not been found in other Mesaverde wells at Rulison, this is believed to be a local phenomenon. The productivity and storage capacity of this and other high water saturation zones in the Mesaverde were tested in R-EX by the USGS. No measurable water production was obtained.

II. TECHNICAL PLAN

A. TECHNICAL OBJECTIVE

The technical objective of Project Rulison is to determine whether nuclear stimulation has potential as a completion technique in the tight, deep, thick gas zones of Rulison Field. In order to obtain the data needed to fulfill this objective, the experiment has been divided into 3 phases roughly corresponding to major site activities for the project. These are site acceptability, operational, and post-shot investigative phase.

The relation between the many tasks that make up the Technical Plan of Project Rulison is graphically displayed in Figure II.1 as a simplified PERT type network. The tasks (activities) shown in the network are numbered, and the scope, job description, and estimated costs are presented in subsequent sections.

A simplified planning schedule in the form of a bar chart for Project Rulison is shown in Figure II.2.

B. PHASE I - SITE ACCEPTABILITY

Site acceptability will be established and documented at the end of Phase I with respect to meeting both the project technical objectives and the preliminary safety requirements.

1. Site Acceptability Criteria

To be technically acceptable the Project Site must meet certain pre-determined criteria. The data and interpretation pertinent to the acceptance criteria will be collected and documented in a report for review by the project participants before the site is formally accepted. These criteria are that:

a. The technical data enumerated in the Project Rulison Objective, I.C. (Page 4) can be obtained at this site.

b. The reservoir rock at the site will contain reserves of at least 30×10^9 standard cu ft of gas in place per 640 acres, as determined by the analyses of core, logs, and production test results from the pre-shot drill hole, R-EX.

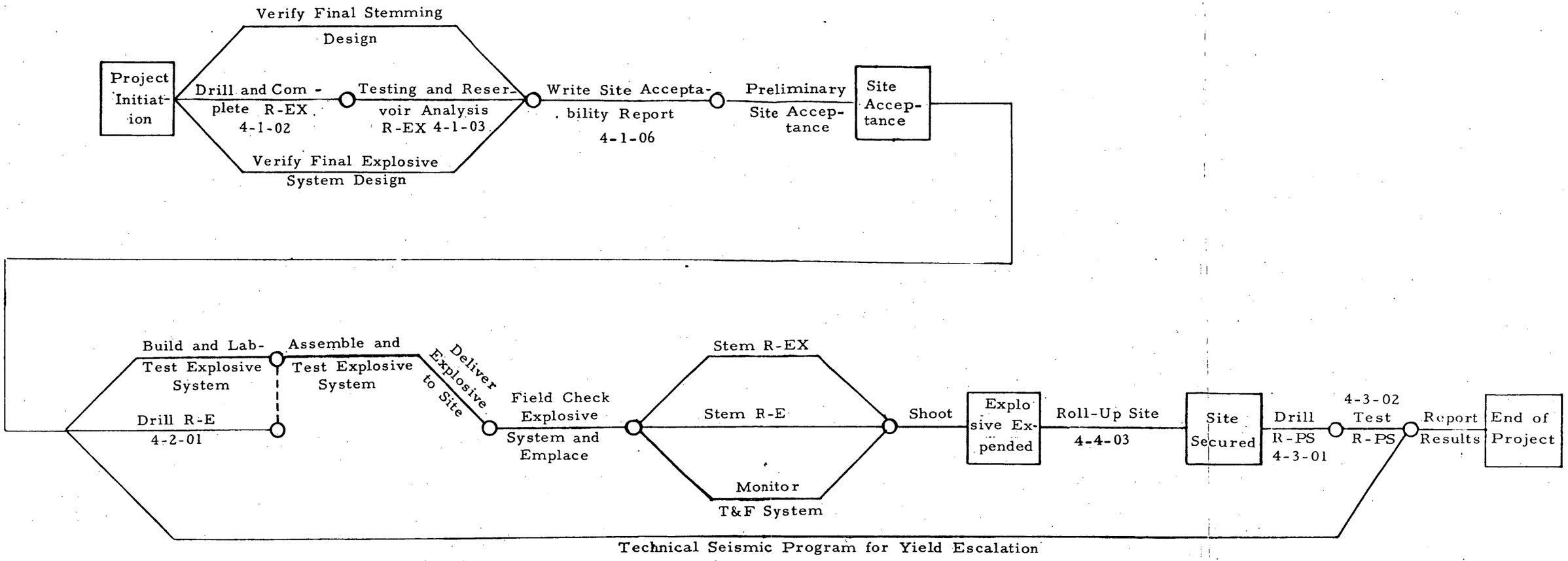
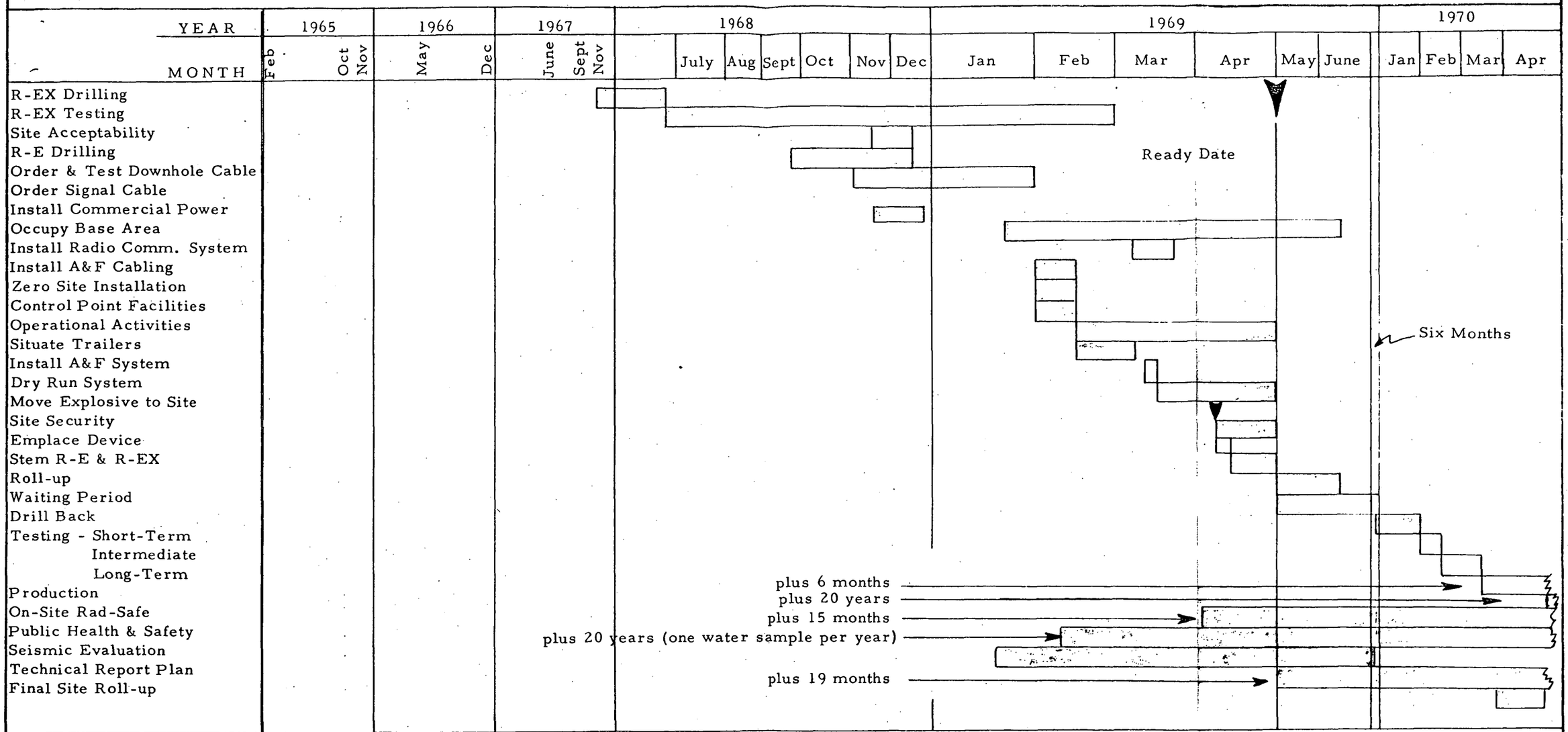


Figure II. 1
Project Rulison Technical Plan
Simplified PERT-Type Network

PROJECT RULISON PLANNING SCHEDULE



Interest in the Feasibility and Site Investigation by Austral Oil Company

CER Conducted Surface Site Tour

Two Test Wells Drilled and Completed

Austral/CER Letter of Intent to AEC

Austral/CER Formal Presentation to AEC

Austral/CER, LRL Actual Site Location

Road Built to Site by Austral

Contract Let for Drilling R-EX

Project Definition Document Initiated

Project Definition Outline and Scheduled Presented to NVOO

Figure II. 2

c. The nuclear explosive can be detonated with all reasonable assurance that it will be completely contained.

d. The other AEC safety and operational criteria will be met.

2. R-EX Drilling and Completion

The R-EX site is in Garfield County, Colorado, in the northeast quarter of the southwest quarter of Sec. 25, T7S, R95W. The R-EX well is located at an elevation of 8,171 ft, 1,695 ft from the south line and 2,236 ft from the west line of this section. This location is shown in Figure II. 3.

R-EX was drilled to a total subsurface depth (TD) of 8,516 ft. Representative intervals of the Wasatch and Ohio Creek Formations were cored and tested and all were found non-productive of water. The well was cased through the Ohio Creek Formation to a depth of 6,367 ft with 7-5/8 in OD pipe. A 6-1/8 in hole was air- and mud-drilled in the Mesaverde Formation from the intermediate casing point to the total depth (TD) of 8,516 ft.

Representative cores and a comprehensive suite of logs were obtained in this Mesaverde section. A 5-1/2 in OD casing liner was cemented through the Mesaverde section and the well was production tested and completed. The geologic and hydrologic information obtained from R-EX will aid in the site acceptability decision.

3. Testing and Reservoir Analysis

A short-term test has been run on the gas producing intervals in the R-EX well in order to evaluate the initial flow capacity in the immediate area of the well. Subsequently, a long-term constant rate production and buildup test will be made on a representative sand body to verify lack of faulting, to ascertain the average flow capacity, and to provide an estimation of the continuity of the sand bodies.

The well testing data will be used to calculate reservoir parameters, such as effective flow capacity, well bore radius, and effective feet of pay. These values will then be used to construct a mathematical model of the pre- and post-shot reservoir in the vicinity of the emplacement area.

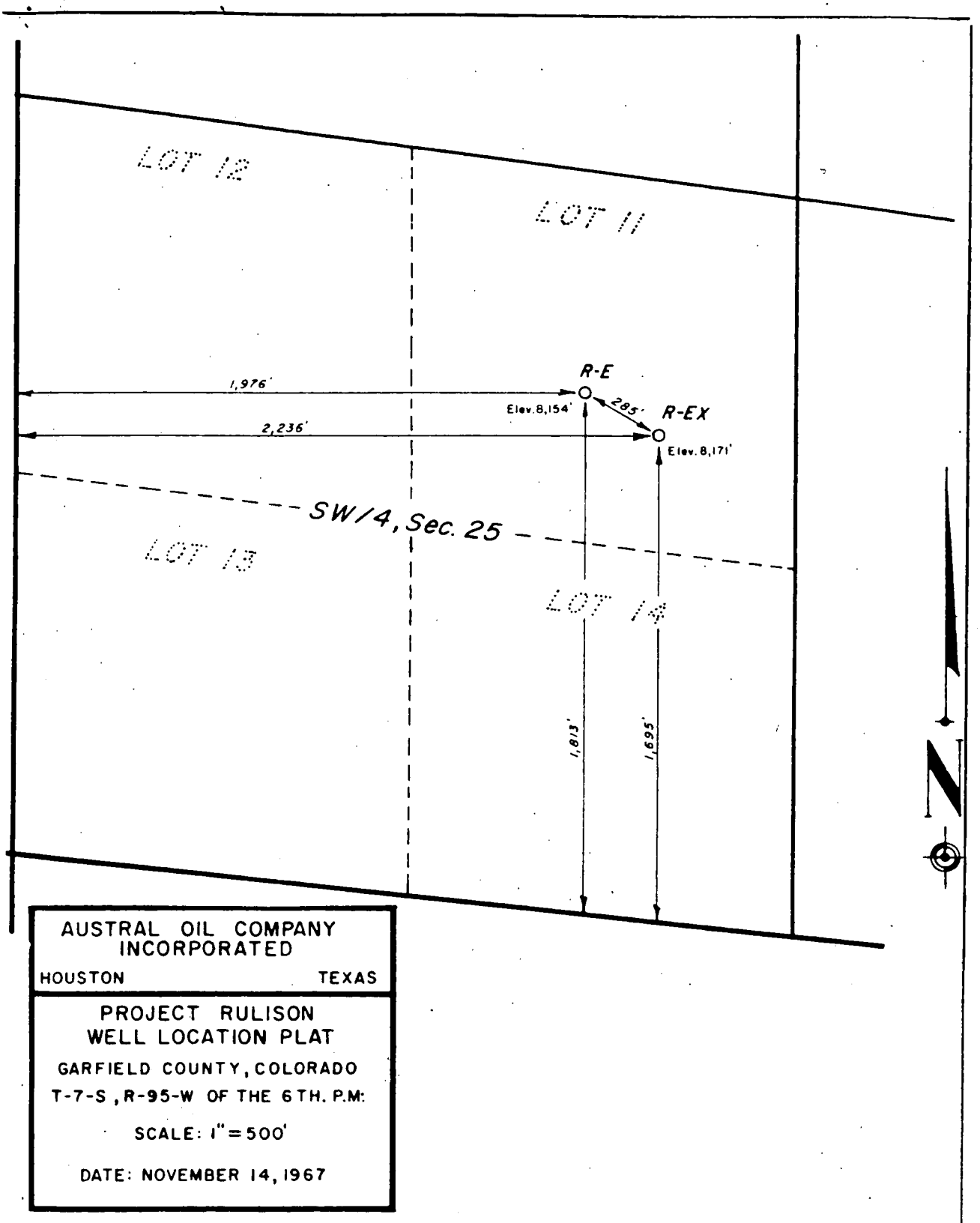


Figure II. 3
Location of R-E and R-EX

The pre-shot model will be used to match long-term production history in the Rulison area and to predict how a non-nuclear stimulated well would perform. This data will be presented in the Site Acceptability Report. The reservoir model will be expanded to include post-shot effects in Phase III. Previous to this, an estimate, ranging from conservative to optimistic, will be made of the anticipated effects in order to predict the nuclear-stimulated well performance. More details of this model can be found in the "Project Rulison Feasibility Study."[1]

C. PHASE II - OPERATIONAL

The operational phase begins with the site acceptance. This phase will include drilling the emplacement well, assembly, testing and emplacement of the explosive system, stemming, detonation, roll-up and securing the site to await drillback.

1. R-E Drilling* and Completion

The emplacement hole, R-E will be drilled approximately 285 ft northwest of R-EX (see Figures II. 3 and II. 4). A 15 in hole will be drilled to a depth of 8, 700 ft, or approximately 270 ft below the proposed working point. Formation characteristics will be carefully documented during drilling operations. Core will be cut over the interval ± 10 ft of the working point and a suite of wet hole logs will be run at the conclusion of drilling operations. A string of 10-3/4 in casing will be run to TD and cemented from TD to 6, 000 ft and from 1, 000 ft to the surface. The casing will be plugged from TD back to the Working Point (WP) depth with cement and then the bottom will be leveled by running a bit to the WP. The stability of the plug will be checked by allowing the weight of the drill string to set on this bottom (80, 000 pounds).

The casing cement quality will be checked by logging. After a satisfactory bond is obtained, the liquid will be removed from inside the pipe. A 9 in diameter by 15 ft long mandrel will be run from ground surface to the bottom of the hole on the drill string. An accurate hole depth measurement will be made. Appropriate representatives will verify that the hole meets specifications.

The drilling and completion program for R-E is shown as a simplified PERT network in Figure II. 5.

* Actual drilling of R-E started on September 29, 1968.

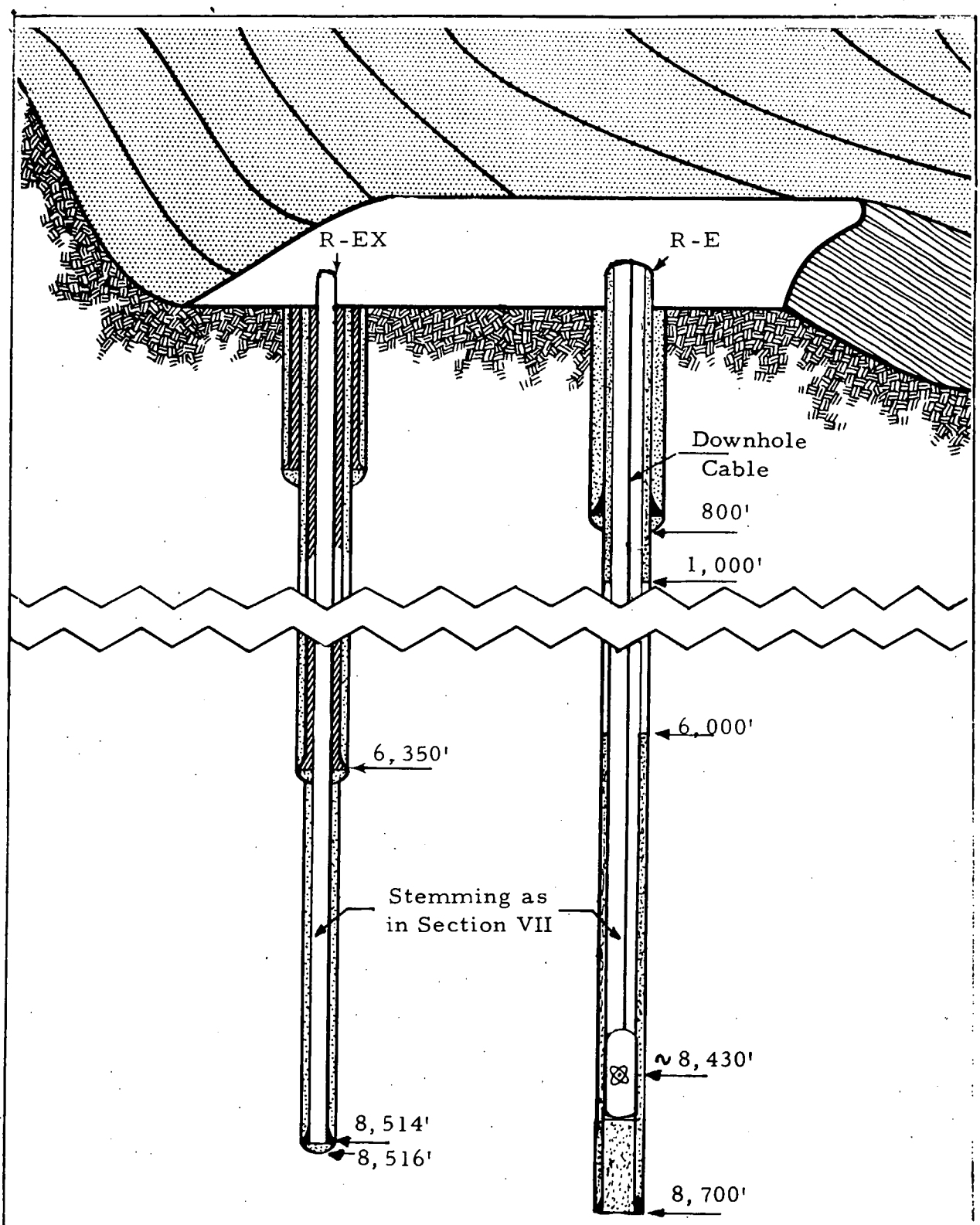


Figure II.4
R-EX and R-E Cross Section - Schematic

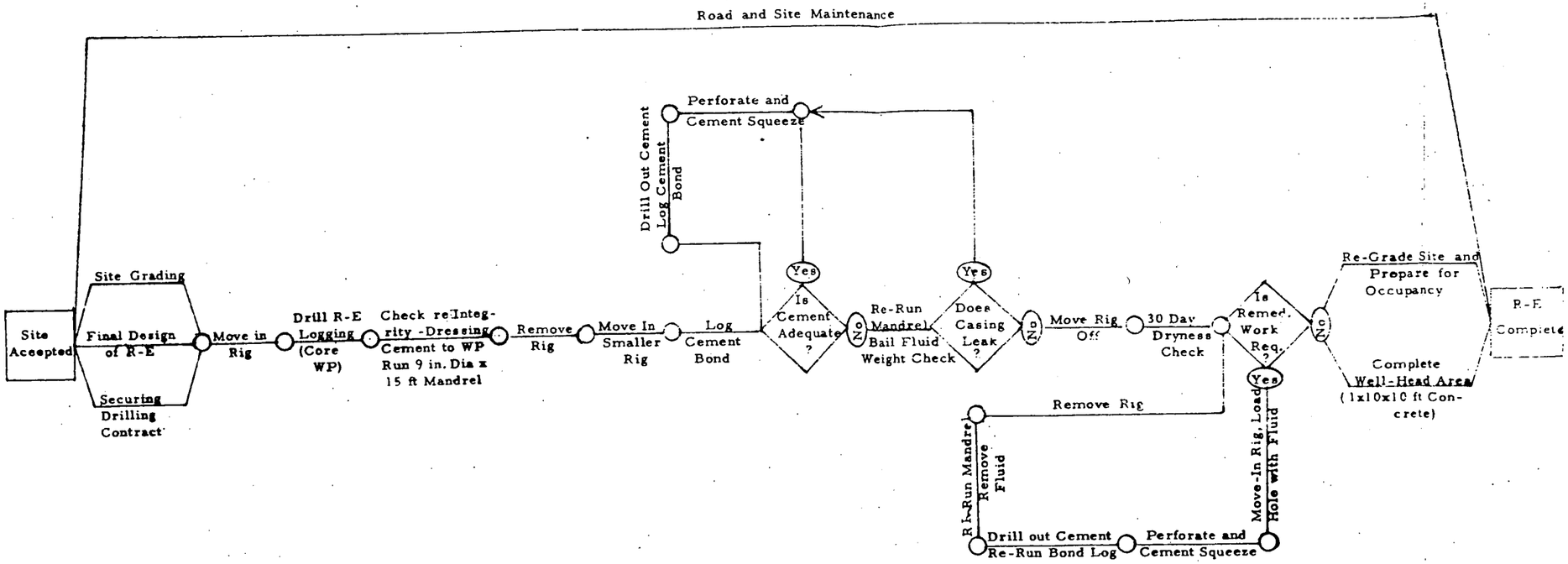


Figure II.5
Simplified PERT Diagram for R-E Completion

2. Predicted Explosion Effects

The experiment is currently designed to use a $40 \pm \frac{20}{4}$ kiloton (kt) nuclear explosive. The yield is believed large enough to provide a guarantee of chimney collapse, and small enough so that seismic motion is within acceptable limits.

The detonation point has been selected at 8430 ft subsurface so that the chimney-fracture zone will occur within a gas-bearing section of the Mesaverde Formation. This leaves a sufficient buffer zone so that possible fracture communication with known water-bearing sands will be improbable. While such communication would not contaminate any water supply, an influx of an appreciable quantity of water into the chimney and fractured zone would compromise the gas well testing program and complicate post-shot evaluation.

For the purpose of these calculations, it is assumed that the depth of the explosion will be approximately 8,430 ft. This assumption is based on an extrapolation of geologic parameters from R-EX.

The following representative geologic and physical features based on data from other wells in the field were used in predicting the effects of the Rulison explosion:

a.	Depth of explosive burial	=	8,400 ft
b.	Median porosity	=	9.7%
c.	Average Water Saturation	=	45.0%
d.	Average overburden density	=	2.35 gm/cc
e.	Average core grain density	=	2.67 gm/cc

Cavity radius was calculated from the correlation of Higgins and Butkovich;[9] chimney height and fracture dimensions were estimated from the data of Boardman, et al.[10]

a.	Cavity radius (r_c)	=	80 ± 10 ft
b.	Effective fracture radius and chimney height	=	370 ± 70 ft

These predictions may be modified as more data become available from the pre-shot well program. Data and results from previous gas stimulation projects will be used to the fullest extent possible in revising these calculations and, if possible, estimates will be made of the extent and values of reservoir permeability that might result from the nuclear explosion.

3. Yield Escalation Program

The purposes of the Yield Escalation Program are: 1) to determine the ground motion as a function of slant range from the WP; 2) to assess the degree of amplification caused by the acoustic impedance mismatch between an overlying alluvial layer and the underlying rock layers; and 3) to assess, if possible, the effect of the geologic formations on the seismic signals. From the results of these investigations and the results of the structural response program described in the Safety Plan, an approximation can be made of the extent to which the yield of possible follow-on explosions can be safely increased.

To aid in achieving these objectives, it is planned to acquire ground motion data over an extensive section of the Colorado River valley in conjunction with the seismic safety program. It is tentatively planned to make ground motion velocity measurements up to about 40 miles from SGZ. For this purpose, about 9 stations are planned, 5 of them spaced at significant locations between Morrisania Mesa and Grand Junction, and 4 spaced upstream to the Glenwood Springs-Carbondale area. It is planned to take velocity data in 3 components of motion--vertical, radial and tangential.

Tentative locations for the stations have been selected primarily on the basis of map study. It is probable that a site survey will result in changes in the selections. For economy of effort, station locations will be coordinated with those required for the safety program. Tentative locations of the stations for the technical program are shown in Figure II. 6.

Typical cultural features of interest from a seismic standpoint are tabulated in Table II. 1. The tabular values of predicted peak accelerations are based on the maximum predicted yield of 60 kt, and using a scaling law of $a = 3.4R^{-2}$ for hardrock locations (a is in units of gravity and R is in statute miles). An amplification factor of 2 is assumed for locations on alluvium.

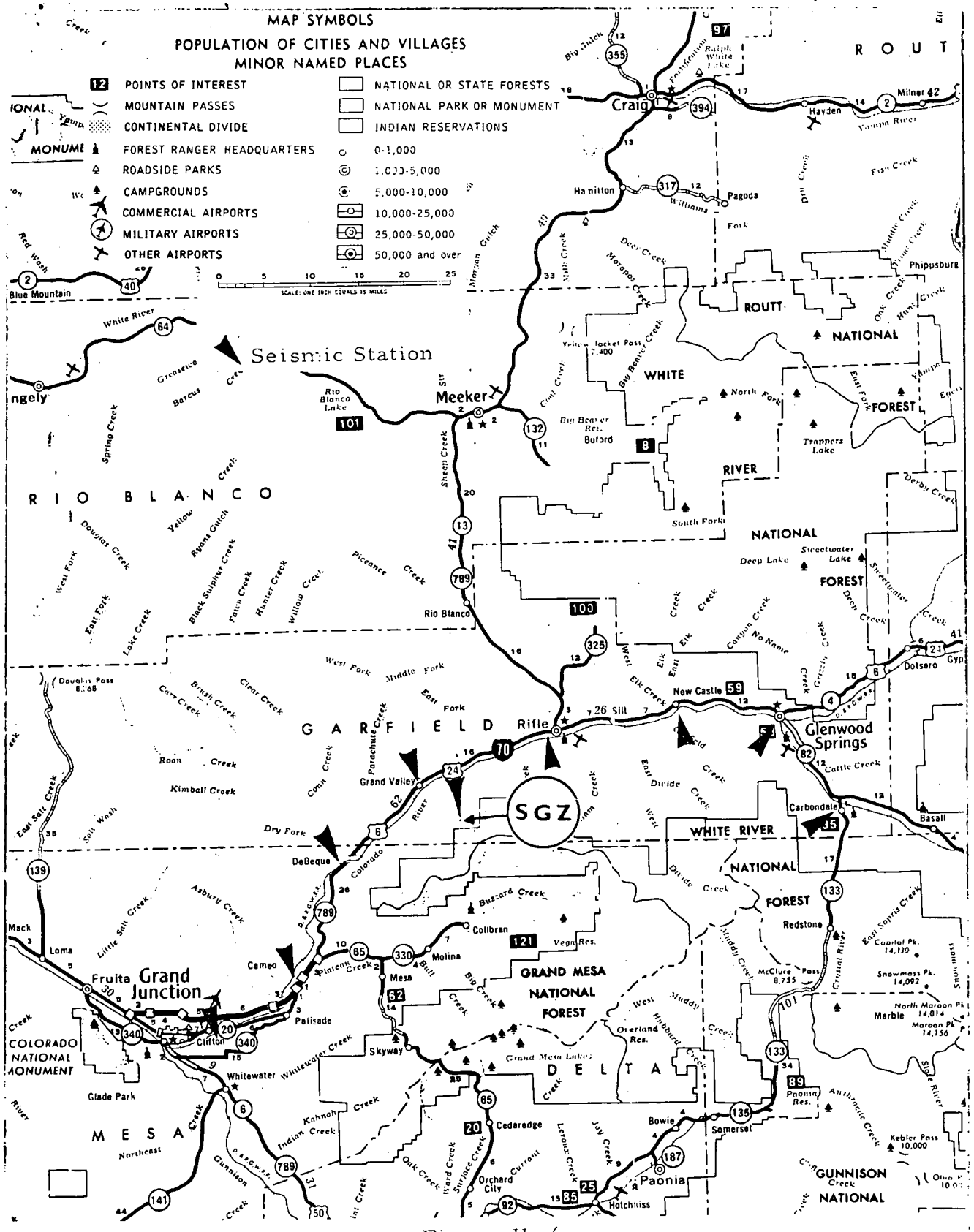


Figure II. 6
Proposed Seismic Station Locations

TABLE II. 1

POTENTIAL MAXIMUM ACCELERATIONS

Feature Nearest to SGZ	Slant Range in Statute Miles	Predicted Peak Ground Acceleration in Units of Gravity Based on 60 kt
CP	2.6	0.53
Gas Well	3.1	0.37
Residence	3.5	0.56*
Railroad and Highway	5.2	0.25*
Road Bridge	6.1	0.19*
Town, Grand Valley	6.1 - 6.6	0.19 - 0.16*
Power Station	6.4	0.17*
Anvil Points Plant	8.2 - 8.6	0.052 - 0.047
Anvil Points Mine	9.0	0.043
Union Carbide Plant	11.2	0.057*
City, Rifle	12.0 - 13.0	0.048 - 0.040*
City, Grand Junction	39.0 - 41.0	0.0044 - 0.0040*

4. Nuclear Explosive System

The explosive selected is a $40 \pm \frac{20}{4}$ kt nuclear explosive of minimum diameter and maximum reliability for the environment expected in the Rulison emplacement hole. It has been previously tested by LASL at the Nevada Test Site (NTS), and has been modified to employ a more compact but fully tested mechanical safing system.

* Alluvial Value Assumed Appropriate

Since a yield verification program is not intended, the given uncertainties must be considered when evaluating effects information.

5. Emplacement and Stemming

Prior to the emplacement operations, the following sequence of events shall have transpired:

a. All construction work, drilling operations, etc. will have been completed.

b. All trailers and/or shacks are to be operational with utilities connected and operational.

c. The stemming material and emplacement equipment will be on location and operational. The winch and head frame will have been previously tested to their related capacity.

d. The LASL furnished electronic equipment racks will be installed in trailers and/or shacks.

e. The LASL furnished trailer will be spotted and connected.

f. The downhole cable will be installed on the winch, lowered into the emplacement hole and rewound on the winch. This should properly tension the cable on the drum. A mandrel run is then made using a downhole weight (cable and mandrel) of approximately 20,000 pounds.

g. The LASL personnel will have installed, connected and checked out the LASL furnished electronic gear.

h. The LASL furnished dummy downhole package is to be placed in the "Wellhead Shack," connected, checked out, lowered to the bottom of the emplacement hole, checked out on the bottom, removed from the hole, returned to the "Wellhead Shack," and disconnected.

i. The explosive package will be delivered to the site, unloaded placed in the "Wellhead Shack," connected and checked out.

The emplacement of the explosive package will be accomplished using a winch, head frame and double-armored electrical cable. This cable will provide both the support and electrical requirements.

The package will be removed from the "Wellhead Shack" and hung over the hole on the head frame. After completing the final check-out of the signal and diagnostic system, the package will be buttoned up and lowered to the bottom of the hole.

The downhole cabling will be checked out and, concurrently, the stemming equipment will be moved into position. After completing the cable checks, the stemming operation will commence. The downhole cable will remain connected to and supported by the winch and head frame during the complete stemming operation and a constant tension will be maintained on the cable.

The stemming operation will require a hopper, front-end loader, and equipment for sounding the hole to determine the stemming progress. The stemming material will be emplaced at a variable rate dependent on the depth. The downhole cabling will be periodically monitored during the stemming operation.

After completing the stemming operation, a 3,000 psi sealing fixture will be installed on the emplacement hole. This fixture will also act as a cable support. The cable will be removed from the winch and head frame and all equipment and trailers not needed at SGZ will be removed from the area.

6. Arming and Firing, Monitoring and Documentation

The explosive will be monitored, detonated and its performance documented over hardwire connections to the arming and firing (A&F) trailer located approximately two miles from SGZ. The procedures employed will comply with AEC Manual, Chapter 0560, throughout the time the device is on-site. An austerity approach has been employed which will furnish only those services required to detonate the explosive and document its performance. The following services normally provided as a convenience to participants are not presently planned and cannot be made available unless requested well in advance of their need:

a. Radio timing signals

b. IRIG time codes

c. Automatic, precise time signals

d. Time of detonation to millisecond accuracy*

* A time of detonation will be determined

e. Zero test and/or Fidu signals

D. PHASE III - POST-SHOT INVESTIGATIONS

1. General

The post-shot program basically will consist of:

a. Re-entry into the nuclear "chimney" and evaluation of post-shot reservoir production characteristics from which the effective chimney and fracture zone geometry can be determined.

b. Evaluation of possible radioactive contamination in gas and "cleanup" techniques.

c. The mathematical pre-shot reservoir model will be modified to include the nuclear explosive effects.

d. Evaluation of ground motion and structural response in the Rulison area, i.e., Morrisania Mesa, Colorado River, Plateau Creek and Parachute Creek Valleys. Extrapolation of these motions will be analyzed in order to predict responses at higher yields.

2. R-PS-1 Drilling and Completion

If possible, the post-shot well designated R-PS-1 will be a re-entry of the emplacement hole. Alternatives are shown in Figure II. 7. Re-entry drilling will be delayed until approximately 6 months after shot time to allow the iodine-131 and other short half-life isotopes to decay. The wellhead will be removed, and the stemming material will be circulated out of the well bore. The cable will be pulled out and the chimney entered through the bottom of the casing.

If mechanical conditions preclude entry into the chimney in this manner, the top of the chimney will be entered either by milling a window in the wall of R-E and deflecting the new hole out alongside the initial emplacement hole, or re-entering R-EX, cleaning out the casing as far as possible, milling a window in the 7-5/8 in casing, deflecting the well out from this window, and directionally drilling over and into the chimney top. The selection of the alternatives will be based upon the depth at which adverse mechanical conditions are encountered in R-E and the best course of action aimed at reaching the chimney top.

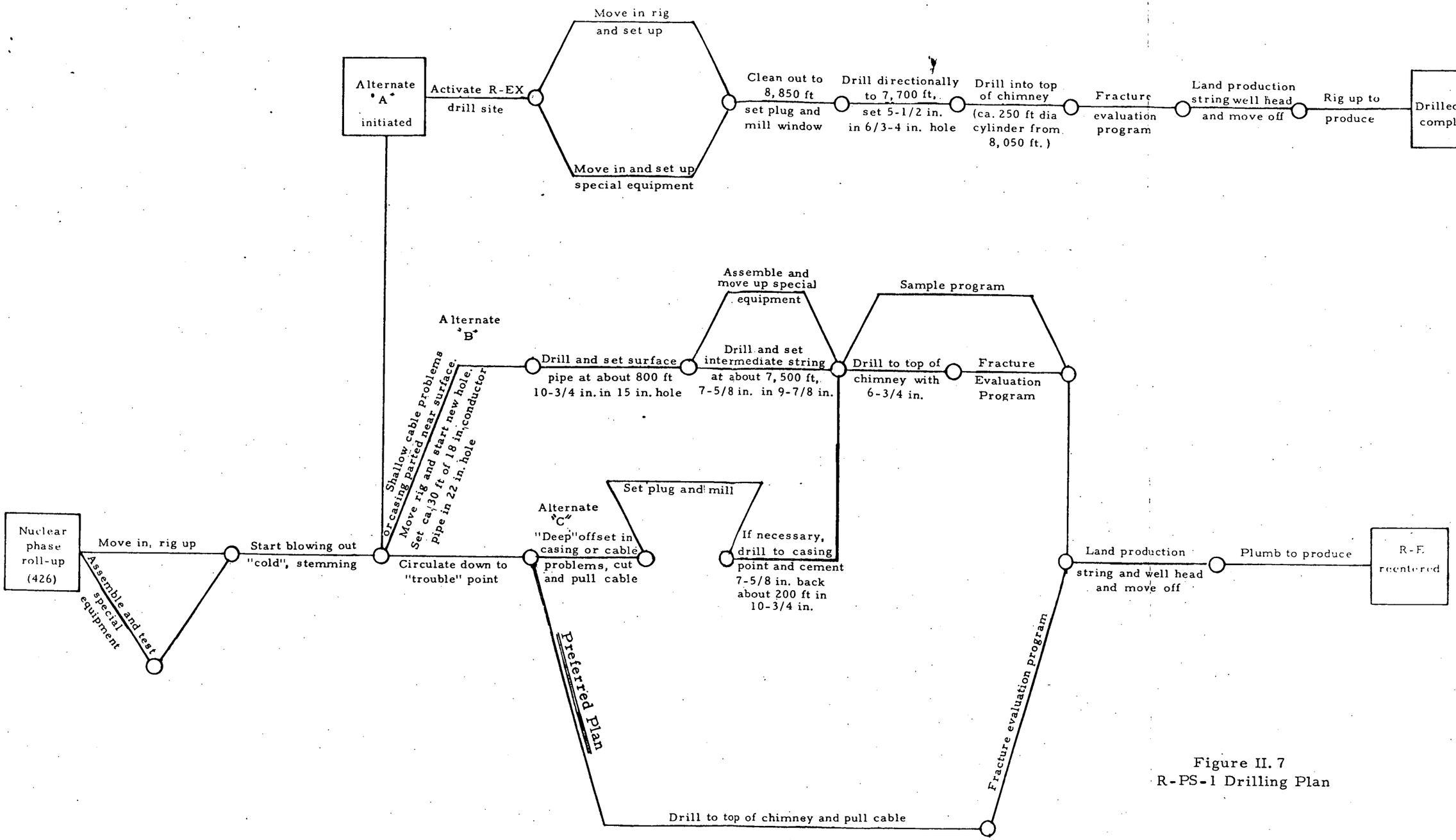


Figure II. 7
R-PS-1 Drilling Plan

The extent and orientation of fracturing above the chimney will be investigated by logging, photography, or packer-spinner survey techniques, depending upon hole conditions and the degree of reliability expected from the data.

The returning fluid stream from the R-PS-1 drilling operations will be monitored for radioactivity and periodic samples analyzed for chemical and isotopic composition. After chimney re-entry, tubing will be run, the equipment cleaned if required, the rig released, and the "Christmas Tree" and production equipment installed.

The results of the gas analyses will be compared with safety criteria and, if favorable, production testing will begin.

3. R-PS-1 Testing and Reservoir Analysis

Surface recording downhole temperature and pressure gages will be run in the tubing immediately after completion. Subsurface pressures and temperatures will be monitored before and during well testing operations.

The production testing will be accomplished in three phases: 1) very short-term transient testing to evaluate chimney volume, 2) a series of intermediate-term isochronal tests to evaluate apparent chimney and fracture zone volume and apparent fracture radius, and 3) the final long-term production test to evaluate the flow capacity and producing characteristics of the nuclear-stimulated well. The pressure and flow rates will be monitored during the producing life of the well. It will be necessary to periodically retest the well to determine if the created volume and/or associated fracture permeability has decreased as the reservoir pressure declines.

From these tests, an estimate of the fracture flow capacity, chimney volume, fracture volume, and effective fracture extent can be determined. Using these data, the pre-shot reservoir model will be modified. This final model can then be used to predict deliverability for various production practices and the nuclear stimulation potential of the Rulison area.

4. R-PS-2 Consideration

A second post-shot well (R-PS-2) has been recommended by the BuMines. It would consist of re-entry of R-EX if R-EX is not used as one of the alternatives by R-PS-1.

R-PS-2 has been recommended for the following reasons:

a. A post-shot well in the fractured zone outside of the chimney should provide data on lateral extent, frequency, and capacity of fractures to permit earlier, more accurate predictions of gas deliverability and recovery than can be obtained from only production tests of the chimney well.

b. It is desirable to obtain data which will permit comparison of deliverability and radioactive contamination of the chimney well with a well outside the chimney. It may be possible to achieve sufficient productivity with a significant reduction in radioactivity by producing from the fractured zone rather than the chimney.

Mutual agreement has not been reached on the need for R-PS-2 to fulfill the technical objectives. While it is true that a well in the fractured zone might enhance the stimulated reservoir model it is doubtful that any incremental information gained would justify the additional cost. In any case, the evaluation of the model and predictions of deliverability must depend upon a relatively lengthy production test. Although it may be possible to have less gaseous radioactive contamination, a greater probability is that a fracture zone well having the capacity to be an adequate producer, would be intimately connected to the chimney and therefor have approximately the same contamination.

5. Product Radioactivity

During long-term production testing, the feasibility of producing gas of low radioactivity will be investigated. Periodic samples of the flared gas will be taken and assayed for tritium and krypton-85 activity and for gross particulate or liquid activity. The effectiveness of particulate and liquid separation systems in removing activity from the gas stream will be investigated if necessary. The decrease of activity with time and the effects of dilution with gas from other wells will be evaluated.

6. Yield Escalation Evaluation

The ground motion data acquired at the time of the explosion will be reduced and analyzed to provide data on signal peak amplitudes, duration, and frequency as a function of slant range from the working point. It is intended to derive from these data a scaling technique which will apply to the area for a 40^{+20}_{-4} kt yield. With the results of this effort, the structural response investigations described in the Safety Plan, and appropriate assumptions based on all available data, a prediction can be made of explosive yield for use in optimum nuclear stimulation of additional wells throughout the unit.

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C. OPERATIONAL CONTROL

Operational control of the general site area during the nuclear operations period will be under the DONO. He will be assisted by an Operations Control Center (OCC) and an advisory panel. The OCC, located in the control point (CP), is the on-site focal point for receiving and disseminating information of project activities, except for public information, which will be released by the Joint Office of Information (JOI). Duties of the OCC include:

1. The preparation, administration and dissemination of Area Control Plans, including operation, muster procedures, security sweeps (air and ground), emergency site evacuation plans, etc.

2. The coordination of operational site nuclear activities between participating agencies, except those activities of a technical nature under the control of the LASL Operations Director.

3. The communication center for reporting significant items such as accidents, incidents, support required from the PM, which may require OCC action.

4. The coordination of requirements for operational air support.

5. The accomplishment of other actions as directed by the DONO.

During shot time, CP personnel will be limited to those required for the operation. An Air Operations Center (AOC) will be established in the AEC-OCC Trailer at the CP to control on-site aircraft activities as approved by the DONO. Arrangements will be made with the Federal Aviation Administration (FAA) for required air space closure on D-Day.

Miscellaneous real estate and other support requirements for on- and off-site AEC-related technical installations will be coordinated with the Program Manager through the DONO's staff.

At about D-3 days, the DONO will convene his Advisory Panel and hold readiness briefings at a convenient facility near the Rulison project. The Advisory Panel for Rulison will consist of experts on the various aspects of nuclear operations and safety, and will be chaired by a senior LASL scientist. All safety and control preparations and weather conditions are thoroughly reviewed prior to making a recommendation to the DONO.

During the periods of area closure, beginning several hours before H-Hour, civil authorities and security guards will be utilized to man roadblocks on the perimeter of exclusion areas. Qualified, cleared security personnel will control access to classified areas.

Areas to be closed and controlled on shot day will be determined by the DONO based on predictions of possible maximum ground motion and on the maximum credible radioactive fallout intensities and patterns. For the purpose of closure control, a specific downwind sector will probably not be determined until D-2 days and will be subject to change up to the final readiness briefing shortly before shot time. Wind trajectory and velocity will be determining factors in the final selection of the downwind sector.

D. AREA CONTROL

Flexibility will be maintained in the area control plans to permit rapid and orderly repositioning of roadblock personnel to accommodate special safety requirements and delays in execution of the event. Adequate communications between the OCC and roadblock personnel will be required. Roadblock personnel will maintain their positions until relieved by the DONO.

Evacuation of area residents, if required, will be directed by the DONO. Prior arrangements will be made for a complete survey of the area for several miles around the shot point, documenting the number and location of residents, residences, and livestock; the radius of the survey area will depend on predictions of ground motion and potential radiation fallout in the unlikely case of venting. In addition, it is planned that a survey will be made to a greater distance (estimated at not more than 20 miles) in a tentative pre-selected downwind sector. Details of this survey are presented in Section IV.

To maintain proper control over the closed areas, it will be necessary to make a thorough road survey, select roadblock locations, and prepare area control maps. An AEC-approved control plan will be prepared detailing the various requirements, activities, and responsibilities. Consideration of potential rock-falls or slide areas near roads and railways will be included. Early contacts with state and local civil authorities are desirable and necessary.

Post-shot re-entry teams will be on standby pre-shot at either the CP or some predetermined location. The DONO will determine when re-entry proceedings can commence.

E. SECURITY AND CLASSIFICATION PROGRAM

The objectives are to provide security, accountability and safeguards for classified matter and material prior to, during, and after the operational period. Information will be classified in accordance with the AEC classification guide for Project Rulison. Access to classified matter will be limited to those who have appropriate clearance status, are authorized such information, and have a "need-to-know" in the conduct of their organization's support of the project.

Security will commence the day the explosive arrives on-site (approximately D-3 weeks) and will be confined to the SGZ area. An exception to this will be the need for a security station to control access at the A & F Trailer at the CP for one or two days at shot time. Classified document storage will be at the explosive location until such matter is removed to the A & F Trailer prior to the event. Classified mailing addresses cannot be established prior to the explosive arrival unless expressly approved by the DONO.

The "Buddy System" concept will be employed by all personnel, including security guards, within fenced security areas. There will be no security provided for the cableways other than that which can be furnished by two men by the Wellhead Shack. No additional guard personnel will be required for sweeps, musters, roadblocks, or add-on activities in connection with the project. Guards on overtime and personnel of other organizations on-site will be used for this purpose.

It is assumed that following detonation a security fence will be erected and routine checks will be provided, as necessary.

F. DEVICE, SOURCE AND NUCLEAR MATERIAL

The objectives are to provide security, accountability and safeguards for the device and components containing Source and Nuclear Materials which are shipped to the Rulison site.

Arrangements for movement of the device and other Source and Nuclear Materials to the Rulison site will be made by Albuquerque Operations Office.

Accountability, storage, movement, control and safeguarding of SNM will be provided by the DONO beginning with the arrival of the material at the Rulison site.

IV. SAFETY PROGRAM

A. INTRODUCTION

1. Scope

The Safety Program for Project Rulison includes the planning of effort and support for public and project personnel safety prior to and during the Operational and Post-shot Investigation phases. It includes development of plans for:

a. radiological safety;

b. public health and safety, including evaluation of any possible effects on the surrounding ecological system;

c. meteorological support to the radiological safety effort;

d. peak ground motion and structural response predictions, the measures required to document the ground motion, and the response of structures to the ground motion;

e. evaluation of the need to evacuate occupants of seemingly susceptable structures;

f. measures to evaluate the safety of mines, wells, and pipelines; and

g. study of geologic, geophysical, and hydrologic considerations related to the containment of the explosion and the protection of aquifers from contamination by radioactive materials.

2. Principal Assumptions

The explosive yield will be $40 \pm \frac{20}{4}$ kt with a depth of burial of approximately 8,430 ft in R-E. Drillback activities will not commence until D-Day plus 6 months. Major deviations from the foregoing principal assumptions may require modification of detailed assumptions in planning the Safety Program.

B. RADIOLOGICAL SAFETY -ON-SITE

On-site radiological safety is required to safeguard project personnel during and after the explosion, during drillback activities, to assure the safety of neighboring populace, and to document effluent release, if any. The probability of effluent release at the time of the explosion is considered to be effectively zero, as discussed in IV. E. 1., but the contingency is nonetheless considered in the planning.

In general, the radioactive isotopes of interest are those of krypton, xenon, iodine, and hydrogen (tritium). In the absence of prompt effluent release and with delayed drillback, consideration needs to be given only to the longer lived isotopes, for example, tritium and krypton-85. The latter with half-lives of 12. 26 and 10. 4 years, respectively, may be a problem until their concentrations are diluted to values below the maximum permissible concentration (MPC). Activities recovered in particulate form, if any, may include other long-lived isotopes. All radioactive waste must be disposed of in a safe and effective manner.

1. Equipment Installation

Prior to the arrival of the nuclear explosive, the equipment required for an effluent radioactivity documentation system will be installed on-site, calibrated and tested. It is currently planned that this equipment will consist of 9 remote area monitoring system (RAMS) and air samplers which will be arrayed around SGZ at approximately equal spacings on a radius of a few hundred ft. An additional RAMS unit and air sampler will be mounted on the cable support at the wellhead. The RAMS data will be transmitted by hard wire to the CP for readout and communicated to the OCC.

An Access Control trailer and a Radiological Measurements trailer will be installed at the CP location. The Radiological Measurements trailer will be equipped for analysis of air sampler filters for particulate and iodine activities for maintenance, calibration and test of monitoring equipment; for area radiological monitoring; for dosimetry reading; and for a limited bio-assay capability. The Access Control trailer will be equipped for personnel decontamination and to issue personnel, dosimeters, anti-contamination clothing and for respiratory protection devices. A steam-cleaning capability for equipment decontamination and a laundry capability for contaminated clothing will be provided.

2. Radiological Safety Operations

After detonation, a team of radiation monitoring personnel will re-enter the SGZ area to ascertain prevailing conditions and to determine the degree of radiological control required to permit renewal of work. When conditions permit, they will recover air filter samples collected since shot time and return them to the Radiological Measurements trailer for analysis.

At the direction of the DONO, the peripheral RAMS units and air samplers will be taken out of service. At the outset of the pre-drillback waiting period, the Access Control and Radiological Measurements trailers will be moved to suitable positions near SGZ. Access to the SGZ will then be restricted to the Access Control trailer route by erection of suitable fencing and warning signs. Fencing will be designed to exclude livestock and other large animals native to the area. A decontamination pad and an evaporation pond of about 1,800 sq ft will be constructed inside the fence line for use in decontaminating equipment, e.g., drilling and logging tools. The decontamination pad and pond will be sealed to avoid the possible percolation of radioactivity into the ground water of the Battlement Creek valley.

During the pre-drillback waiting period, the site will be secured and inspected daily for radioactivity and integrity of equipment. One RAMS unit and air sampler will be continued in service at SGZ. The wellhead, monitoring, and sampling equipment will be covered to contain any possible leakage of radioactivity and to assure that it is detected and sampled without contamination from other sources, e.g., possible Chinese or French test. Paper and charcoal filters will be assayed daily for particulate and iodine-131 activity.

During drillback activities, access to SGZ will be through the Access Control trailer as required by the DONO. Personnel dosimetry, anti-contamination clothing and respiration protection devices will be used as required. An appropriate blowout preventer and containment system will be used during drillback activities. Portable radiation monitors and air samplers will be used to detect hazard on or near the drill rig and, if necessary, a particulate removal and gas filtration system will be used to treat the drilling returns. With delayed drillback, it is unlikely, however, that the gas filtration system will be necessary and that particulate removal would be adequate with conventional separation equipment. Radioactive drilling returns, if any, and other materials which cannot be decontaminated to acceptable activity levels, will be disposed of in a manner satisfactory to the AEC.

During drillback activities and reservoir testing phase, the effluent gas will be continuously monitored for gross gamma and tritium beta activity. The monitoring system will include visual and audio alarm features. In the event of detection of unacceptable levels of radiation in the discharge gas, the drilling or testing operations will be suspended and alternative methods of operation chosen. Examples of these are use of a gas recirculation system and of improved facilities for gas dilution. Gas and liquid samples will be collected periodically and assayed for radioactivity. Sample collections will be made when deemed advisable by the PM or the DONO. Contaminated liquids recovered during testing will be disposed of in a manner satisfactory to the AEC.

C. PUBLIC HEALTH AND SAFETY - OFF-SITE

Detailed planning to assure off-site safety requires further investigation and study of the surrounding area to determine (1) the distribution of the human and milk-cow population; (2) the location of structures and mines which might respond to ground motion in a manner hazardous to any occupants; (3) the location of agricultural and industrial producers who might be affected by possible release of radioactivity; (4) the location of water sources used for human consumption which could become contaminated; (5) the amount and trajectory of any possible radioactive effluent; (6) the prediction of possible effects on the ecological system.

1. Area Surveys

A general survey will be made of the distribution of human and milk-cow population based on census data and information obtained from county agricultural agents or other official sources. A detailed survey will be made of farms and ranches out to a radius of several miles depending on the predictions of ground motion amplitudes and potential radiation dose in the unlikely case of venting. See Figure IV. 1 for a map of the area around SGZ to a radius of 25 miles. The detailed survey will document the number and location of people, residences and livestock. It is estimated that this survey will require visiting approximately 500 farms and ranches. In addition, information will be gathered on the transient movement of the people and livestock. These surveys will be supplemented in other parts of the Safety Program (Structural Response, and Mines, Wells and Pipeline Safety) by identification of surface and underground structures which need to be evacuated at shot time to avoid a ground motion hazard to the occupants.

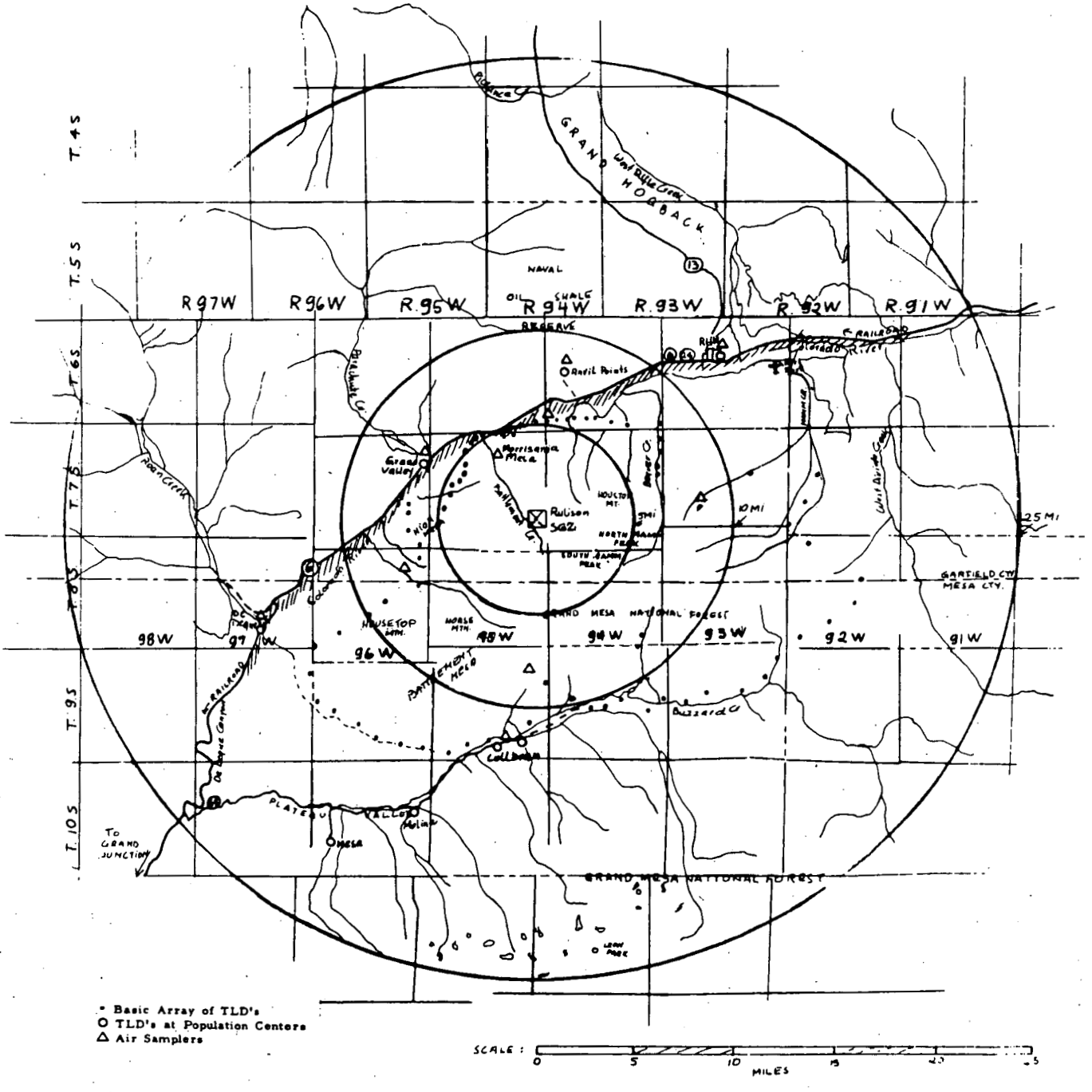


Figure IV. 1
Project Area, Showing Conceptual Arrays of
Thermoluminescent Dosimeters and Air Samplers

2. Prediction of Ecological Effects

Effort will be undertaken to evaluate the ecological system in the Rulison area, to predict possible effects of the explosion on the system and to recommend preventive or remedial courses of action, if appropriate.

3. Dosimetry

A basic array of thermoluminescent dosimeters (TLD) will be established at readily accessible locations as close as possible to the circumference of a 5 mile radius circle around SGZ. Because of the rugged, difficult terrain, many of the TLDs will be installed at greater distances from SGZ than 5 miles. A conceptual array is shown in Figure IV. 1. This array is accessible with a four-wheel drive vehicle. An array located at the closer distances, except to the north and west, would have substantial access problems and extreme difficulty in finding and recovering the exposed TLDs. In addition to the basic array, additional TLDs will be installed, one at each of several appropriate population centers. It is assumed that a total of about 200 TLDs will be required at about 85 locations. TLDs will be recovered at an appropriate time and shipped to the laboratory for reading.

4. Air Sampling

Air samplers will be placed at each populated location within 10 miles of SGZ and at a few approproate locations beyond 6 miles. It is estimated that a maximum of 10 fixed and 4 mobile air samplers will be required. A typical array of fixed air samplers is shown in Figure IV. 1. Pre-shot background sampling will be taken during the 2 weeks preceding D-Day. Paper and charcoal filters will be recovered and assayed for particulate and iodine activity.

5. Ground and Surface Water Sampling

A program will be undertaken, in coordination with the hydrological studies described later, to document the quality of ground and surface water sources in the Rulison area. The location of all ground sources of water in the Battlement Creek drainage area and all surface sources within 5 miles of SGZ will be identified. A water sampling station will be established at each identified source of water including one in Battlement Creek valley in the vicinity of the gaging station in Sec. 15, T7S, R95W, about 3 miles downstream from SGZ and about 1/2 mile

upstream of the nearest habitation. At the same location, a close-in ground water station will be established by drilling a well through the alluvium to bedrock.

Samples will be taken at the established water stations before and after the explosion for determination of background activity and documenting any change in activity. Post-shot samples will be collected periodically from the close-in ground water station and any springs upslope of this station. It is estimated that about 100 samples will be required for this effort. During drillback activities, samples will be taken at the Battlement Creek surface water station as necessary. It is estimated that about 30 additional samples will be required during the year following the explosion. If radioactivity is released to the atmosphere by the explosion, surface water sources in the fallout sector will be sampled as necessary.

6. Milk and Vegetation Sampling

Based on the milk-cow population survey previously described, a milk and vegetation sampling program will be devised. Assuming the cooperation of the farmers or ranchers involved, appropriate sampling stations will be selected. It is assumed that not more than 20 sampling stations will be required. Background samples will be collected prior to the explosion and assayed for radioactivity. Post-explosion milk and vegetation samples will be collected and analyzed as required. It is assumed that not more than 50 each of the milk and vegetation samples will be required.

7. Field Evacuation and Radiation Monitoring

Personnel equipped for radiation monitoring will be fielded according to the Area Control Plan prepared by the DONO. They will document release of radioactivity and evacuate the affected population if required. It is estimated that 20 monitors are sufficient to effect evacuation and to man mobile air samplers.

8. Aerial Radioactivity Monitoring and Sampling

Aircraft assigned radioactivity monitoring and sampling missions in the unlikely case of release to the atmosphere will be orbiting the SGZ in the upwind direction. Other surveillance aircraft may be assigned to ramp standby status and will be used only if a radioactive effluent is released to the atmosphere.

9. Seismic Program Support

Preliminary evaluation indicates that the ground motion resulting from the explosion will be a controllable problem. A public relations program will be developed to inform the populace of the general nature of the ground motion and the measures being taken to avoid injury and minimize damage. It is assumed that this will include a commercial radio broadcast countdown of the event.

A suitable evacuation plan will be developed and, if required, provisions made for transporting, housing, and feeding the affected people or compensating the heads of households for out-of-pocket expenses for them, their families, and for lost time.

10. Medical and Veterinarian Support

If necessary, arrangements will be made to provide medical support or in the evacuation of any invalids living in the project area and prompt medical and veterinarian services in the event of project-related injury to members of the public or to livestock.

D. METEOROLOGICAL SUPPORT FOR RADIOLOGICAL SAFETY

Meteorological support for the radiological safety programs will be provided in order to give a predictive capability for the trajectory and fallout pattern for any potential release of radioactive material to the atmosphere.

1. Climatological Studies

Prior to Phase II, climatological studies will be made of the winds in the Rulison area. These studies will be based on records from the weather archives at the National Weather Records Center and other sources. Mechanical weather stations are being operated at 4 locations (see Figure IV. 1) in Battlement Creek valley and provide data on low-level wind direction and velocity, temperature, and rainfall as functions of time. These data will be used to determine the variability of temperature and windflow caused by the topography and by diurnal effects.

2. Operational Phase Instrumentation

Additional equipment will be installed to support the meteorological effort during Phase II. The mechanical weather stations will be temporarily removed and replaced with wind sensors, the output of which will be telemetered to the CP by either hardwire or radio. To provide supplementary data on winds aloft, "pibal" facilities will be installed at 3 locations. In addition, the Ground Meteorological Device (GMD) trailer and associated balloon-inflation van and generator will be installed at the CP area to provide a temperature and a wind-sounding capability. For readout of the telemetered wind data, a teletype printer will be provided in the CP weather facility. It is assumed that the ESSA-Weather Bureau facilities at Grand Junction can provide weather facsimile and teletype data necessary for evaluation of synoptic weather conditions.

3. Shot Time

As the scheduled time of the explosion approaches, the project forecaster and radiation briefer will make use of the available data to prepare periodic forecasts for the DONO. Based on the postulated maximum credible release model, their predictions will include a possible trajectory fallout sector and predicted dose rate.

Postshot operations will continue until the DONO determines that there is no longer a significant hazard. When this determination is made, meteorological support will be suspended until the onset of the drillback activities. During the interim, the mechanical weather stations will be re-emplaced to acquire additional climatological data in the event of continued use of the nuclear stimulation technique in the Rulison area and for documentation in the event of effluent leakage.

4. Drillback Period

During the drillback and at least in the initial reservoir testing period, limited meteorological support may be required. As indicated in the discussion of on-site radiological safety, in the event of detection of unacceptable levels of radio activity in the flared gas, drilling or testing operations will be suspended and alternative methods employed. If necessary, this will include mobilization of meteorological personnel. In this event, limited pibal effort may be required at SGZ. Assumptions will be made of the most likely form of accidental or planned release of radioactivity to the atmosphere and periodic forecasts will be made of the trajectory of the predicted effluent and of the dose rate to be

expected in affected areas. Meteorological effort will be continued until it has been determined that no further hazard to the populace exists. For documentation purposes, however, mechanical weather recordings are planned at the 4 locations until the conclusion of the period in which gas is flared.

E. GROUND MOTION AND STRUCTURAL RESPONSE

A ground motion and structural response program is required on Project Rulison to satisfy not only the safety requirement, but also the technical objective of evaluating the maximum yield explosion which could be tolerated in the area if the Rulison field were to be developed commercially with the use of nuclear explosives. Accordingly, a tentative network of seismic instrumentation has been presented in the Technical Plan. Definition of the full requirements for seismic instrumentation will be made on the basis of detailed surveys once the project is underway and may require augmentation of the scope of the effort suggested in the Technical Plan.

1. Containment Analysis

Experience at NTS and elsewhere with underground nuclear explosions indicates that, in the absence of major faulting, a nuclear explosion buried at a scaled depth which exceeds 350 to 450 ft/kt$^{1/3}$ will be contained, in the context that there will be no prompt venting of radioactivity. At the assumed depth of burial and the SGZ drainage grade of about one foot in nine, the distance of the explosion point from the nearest free surface will be about 8, 380 ft. Using this value for the depth of burial, the scaled depth of burial is about 2, 450 ft/kt$^{1/3}$ for the most probable yield and about 2, 140 ft/kt$^{1/3}$ for the maximum predicted yield. The latter value exceeds the criterion for predicted complete containment in the full venting context by a factor of at least 4.7. The question of containment, then, is reduced to determation of the absence of significant faulting in the Rulison area and to evaluation of the plans for casing, cementing and stemming. Surface study of the Rulison site area by the USGS and by geologists of Austral, CER, and LRL has developed no evidence of surface faults within a few miles of SGZ. The absence of evidence of significant faulting will be documented. The stemming plan proposed by LASL has been evaluated and approved by the Test Evaluation Panel (TEP) as has the casing and cementing plan. Detailed review of the as-built construction and the absence of significant geological weaknesses will be required by the TEP.

2. Peak Ground Motion Predictions

Preliminary ground motion predictions are made on the basis of empirical equations which are derived primarily from data acquired on Project Shoal, [11] but modified in the light of experience in ground motion recordings from other events. They are restated here:

For Sensor Locations on Hard Rock	One-Sigma Factor
$a = 5.03 \times 10^5 \, W^{0.7} R^{-2.00}$	2.2
$d = 6.04 \times 10^5 \, W^{0.75} R^{-1.73}$	2.0
$u = 8.64 \times 10^6 \, W^{0.73} R^{-1.87}$	2.4
For Sensor Locations on Alluvium	
$a = 1.06 \times 10^6 \, W^{0.7} R^{-2.00}$	1.8
$d = 2.24 \times 10^6 \, W^{0.75} R^{-1.73}$	3.8
$u = 2.94 \times 10^7 \, W^{0.73} R^{-1.87}$	2.4

where

a = peak surface particle acceleration in g units

d = peak surface particle displacement in cm

u = peak surface particle velocity in cm/sec

W = yield in kilotons

R = slant distance in meters

Both the hardrock and alluvium acceleration prediction equations are graphed in Figure IV.2 for the most probable yield of 40 kt, and the predicted maximum yield of 60 kt. For convenience, the range dimension has been changed from meters to statute miles. The areas contained within selected values of predicted acceleration for the case of the maximum yield are shown in Figure IV.3. The corresponding circles for the most probable yield are not shown, but would have radii about 87% of those shown.

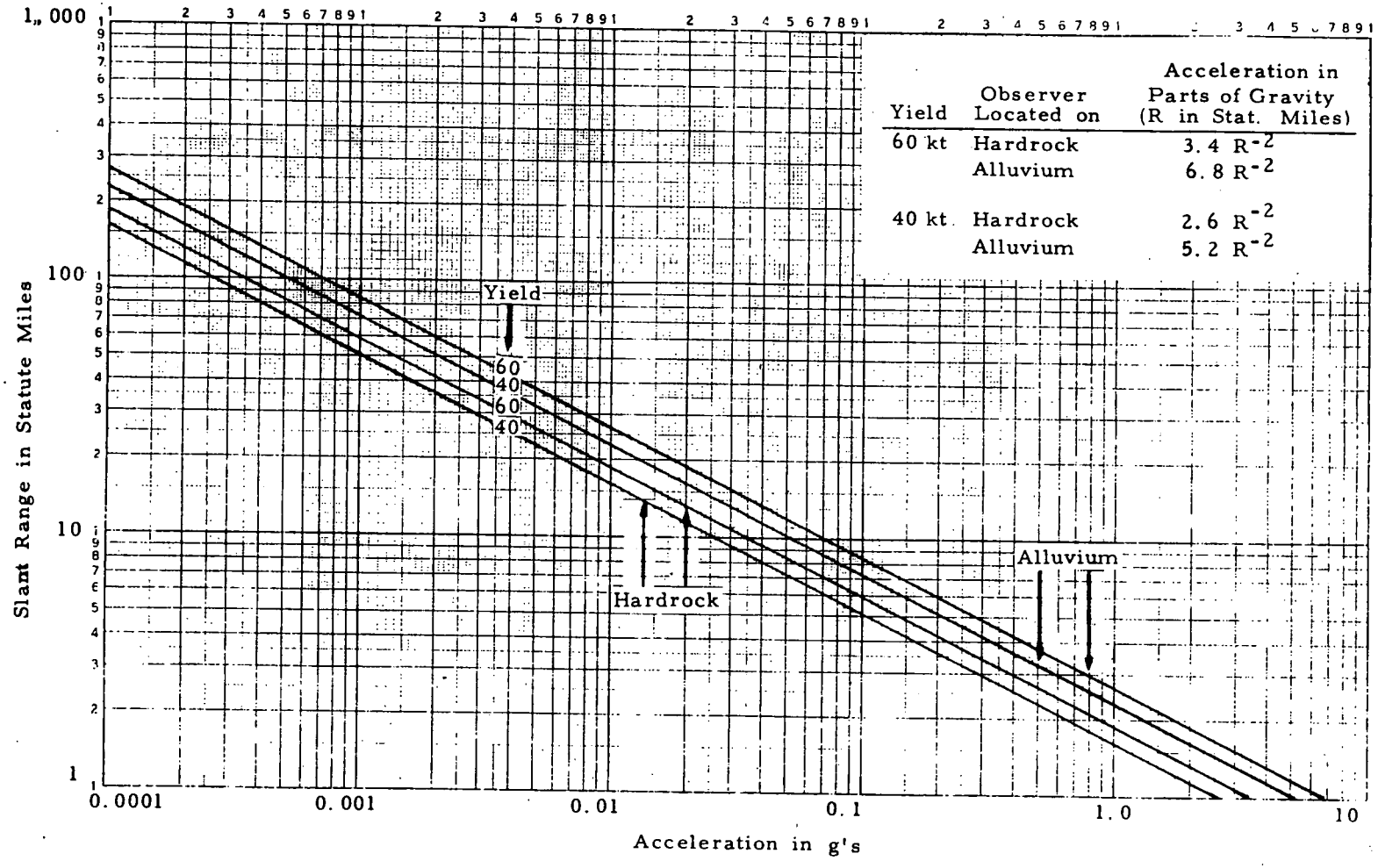


Figure IV.2
Ground Motion Prediction - Acceleration

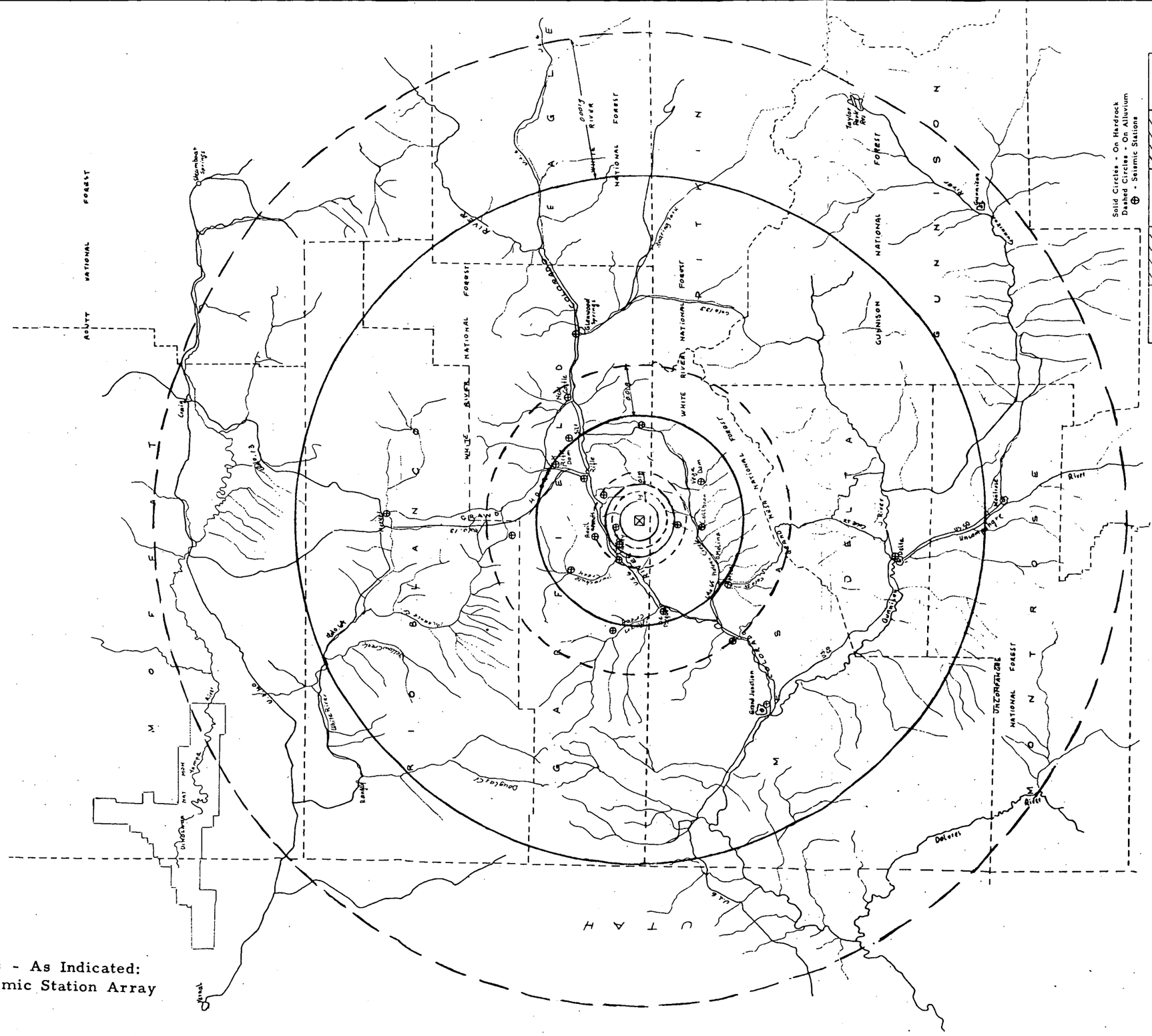


Figure IV.3
Limits of Predicted Ground Motions - As Indicated:
Maximum Yield 60 kt with Typical Seismic Station Array

The geologic features of the Rulison area will be examined, taking full advantage of existing geologic reports, [6] to determine in what locations, if any, it is necessary to modify the ground motion predictions. Based on this examination, final ground motion predictions will be developed for the populated areas and cultural facilities of interest. Included will be identification of ground surface features such as canyon walls, slopes, embankments, dams, and soils supporting highway and railway bridge abutments which might cause property damage or personnel hazards under the influence of ground motion.

3. Seismic Instrumentation

Detailed and specific plans for seismic instrumentation will be based on the final predictions for peak ground motion. It is assumed that a maximum of 23 stations will satisfy both the safety and the technical ground motion study requirements. A typical array of this size is shown in Figure IV. 3.

The seismic instrumentation to be used will record in 3 orthogonal components, one vertical and two horizontal. It is assumed that velocity meters having a long-term recording capability will be used and will be available from government resources. The slant range from the WP to each seismic station will be determined to within $\pm$ 0. 1% unless the technical requirements permit greater tolerance deviations.

4. Structural Response

A program will be undertaken to evaluate the response of structures in the Rulison area as part of the technical objective to evaluate an increase in the yield of follow-on nuclear explosions in the area. It will also provide a basis for evaluating damage complaints, if any.

A preliminary pre-explosion survey will be made to obtain information on the nature, age, condition, and value of structures; the character of foundation materials; local construction costs; and local building practices. In addition, potentially hazardous rock or earth structures will be identified. On the basis of this field survey and study of large-scale maps or aerial photographs, a preliminary estimate will be made of special hazards, probable damage, and repair costs.

Selection will be made of close-in structures for detailed investigation and documentation prior to the explosion. It is assumed that about 300 structures will be selected for detailed documentation. Data will be obtained on the approximate dimensions of each structure, the type and materials of construction and foundation, age and general condition, location and approximate value. Photographs will be taken of existing defects and portions of the structure apparently subject to incipient failure. On the basis of the information gathered in the detailed investigation, an analysis will be made of the anticipated structural response and damage predictions will be developed. In addition, recommendations will be made for deployment of seismic instrumentation and for measures required to minimize structural damage and to avoid personal injury. The results and recommendations will be summarized in a pre-explosion report.

A few days before the event, the structures will be rechecked to determine if there has been any change in condition. At the time of the explosion, observers will be stationed in selected areas to monitor the response of certain structures to the ground motion, to provide reports of perceptibility, and to document any damage in the area attributed to the ground motion. It is assumed that a maximum of 12 observers will be in place at the time of the explosion.

A post-explosion resurvey will be made of the structures whose condition was previously documented. This resurvey will be expanded as required to provide engineering support in determining the validity of damage complaints. An evaluation will be made of any damage occurring from the event and an assessment made of public reaction and damage complaints.

5. Safety of Mines, Wells and Pipelines

A program will be carried out to evaluate the condition of mines, and gas or oil wells and associated pipelines in the Rulison area. Available records will be consulted at the outset to identify facilities of interest. A pre-explosion field survey will be made of the area to investigate the mines and wells and to identify the scope of requirements. There are, within an 18-mile radius of SGZ, 3 oil shale, 2 vanadium, and a few coal mines. The closest to SGZ is an oil shale mine, the BuMines Anvil Points facility, at a distance of about 9 miles. It is assumed that inspection of about 10 miles will be required and that special steps to avoid injury or minimize damage will be required in 2 or 3 cases. The resulting recommendations may suggest mine evacuation and re-entry safety measures as well as steps to be taken to minimize potential damage. Any damage attributed to the explosion will be identified and documented.

Records of wells and pipelines indicate that there are 9 productive gas wells within a radius of 8 miles of SGZ, with the closest at a distance of about 2.8 miles. (Figure IV.4). This is outside of the calculated ground shock damage radius. Associated with the gas wells in the Rulison Field are the Western Slopes gas gathering and transmission pipelines. A post-explosion report will be developed to include the results and observations of the mines, wells and pipelines inspection.

F. GEOLOGIC, GEOPHYSICAL AND HYDROLOGIC PROGRAMS

Technical effort in the earth sciences of geology, geophysics and hydrology has been and will be undertaken to provide data necessary to evaluate the safety of the Rulison experiment.

A general geologic map of the Rulison area is available.[8] Data developed from the R-EX and R-E wells and coordinated with other geophysical and hydrologic data will be used to develop a large-scale geologic cross-section, containing the point of detonation. The geologic map and section will be provided to each project participant concerned with evaluating the probability of containment and predicting the amplitude of ground motion.

A detailed examination has been made of core samples from the R-EX well and of related geophysical logging data. The occurrence of fractures in the Mesaverde section will be documented. Representative core samples will be taken near the proposed detonation point in Well R-E and will be examined for porosity, permeability, density, sonic velocity zones of weakness and compressive and tensile strength. These data will be available for application as required in evaluating explosion effects.

The hydrologic environment of the Rulison area has been sufficiently documented[12] to permit prediction of the effects of the proposed explosion on the ground and surface water supplies and to identify afterward the occurrence of any contaimination or damage resulting from the explosion.

Prior to the explosion, selected water wells and surface water sources around SGZ will be inspected and the condition documented. It is assumed that about 50 wells will be inspected. In the event of complaints of damage to wells, springs, streams, and related production equipment, the items in question will be reinspected in response to the complaints and the results compared with those from the pre-explosion inspection. Complaints will be evaluated after analyses of appropriate water samples or examination of physical damage. The results of the evaluations will be documented in a suitable report.

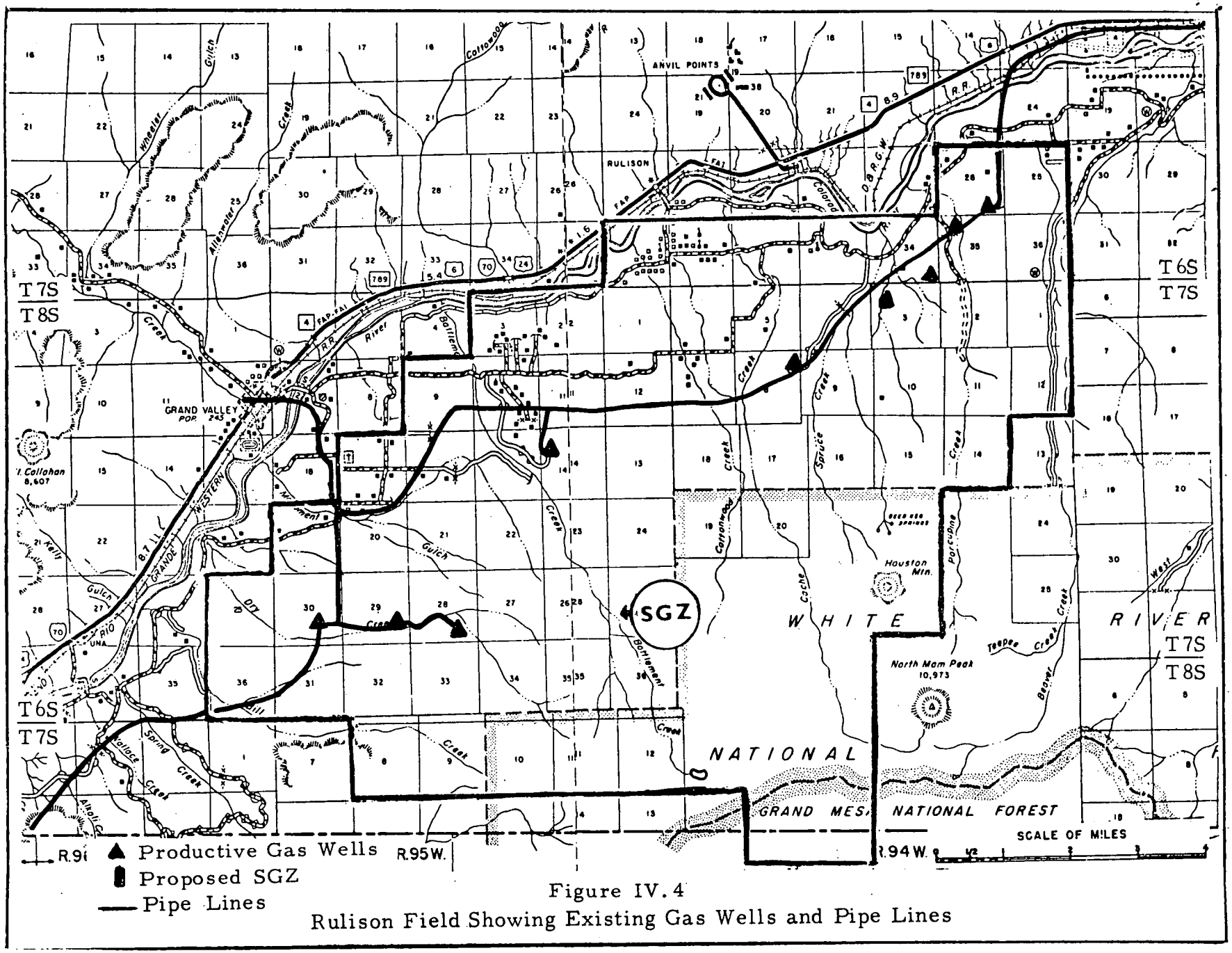


Figure IV.4
Rulison Field Showing Existing Gas Wells and Pipe Lines

V. ADMINISTRATIVE PLAN

A. PROJECT ORGANIZATION

1. Relationship Between Austral and CER

It is Austral's intent that CER (the Program Manager) enter into a Contract with the Government for Project Rulison as a principal. The relationship between CER and Austral will then be governed by an Operating Agreement or contract between Austral and CER.

2. Program Manager's Organization

CER will appoint a Project Director who shall be responsible for directing all functions other than those which are the responsibility of the Government. The Project Director shall act as the responsible point of contact and representative of CER in all dealings with the Government, except for such matters as may be delegated from time to time.

CER shall also provide a Technical Director for the Project Rulison Technical Staff, consisting of one Technical participant provided by the Government Agencies' and such other scientists as are required in the judgment of CER to handle the Project Rulison technical program. The Technical Director will report to the Project Director. The Technical Staff will be responsible for reviewing and evaluating data, formulating and revising technical plans, and recommending activities, procedures, techniques, etc., which are required to meet the technical objectives. Their principal interest will be in Phase I and III reservoir evaluation activities.

CER shall further establish and staff other necessary elements of the Project Rulison organization.

3. Government Agencies' Organization

a. The Atomic Energy Commission, through the Manager, NVOO, shall provide a Director of Nuclear Operations, who will be responsible for assuring preparation for, conduct of,

and control after the nuclear detonation of those matters defined in the Nuclear Operations Plan, Section III. He shall further establish and staff the necessary organizational elements to satisfy those responsibilities.

b. The Department of the Interior shall provide:

1) A participant from the Bureau of Mines to serve on the Technical Staff, who will be responsible for staff participation and the liaison and coordination of activities involving other agencies within the Department.

2) Aid from the U. S. Geological Survey in the definition of geologic and hydrologic aspects of the project.

3) Assistance of other Department agencies, such as the Bureau of Land Management, in obtaining the necessary consents and permits for usage of public lands required by the project.

c. The Los Alamos Scientific Laboratory will assign an Operations Director who will be responsible for the following basic items:

1) Providing criteria and requirements associated with the nuclear explosive system.

2) Furnishing a nominal 40 KT nuclear explosive.

3) Preparing a stemming plan and securing TEP approval.

4) Complying with AEC Chapter 0560 requirements.

5) Supervising the emplacement and stemming of the nuclear explosive.

6) Furnishing and operating the arming and firing system.

7) Arming and firing the nuclear explosive on command of the DONO.

8) Providing radiochemical analyses regarding the prediction of post-shot chimney residue at the end of 6 months.

9) At the request of the DONO, provide technical assistance during post-shot drillback.

B. DIVISION OF RESPONSIBILITY

Project Rulison shall be conducted as generally described in this Project Rulison Definition Plan. At the request of, and with information supplied by, the Government interface organization, those expected to be responsible for performing the activities described are noted in parentheses.

Contractors identified in connection with the Program Manager's responsibilities are NVOO subcontractors. Those left blank will be selected by competitive bid or as otherwise determined by the Program Manager. The following division of effort between the Government agencies and the Program Manager shall apply:

1. General Conditions

   a. Criteria and Requirements

      Except for critical criteria relating to nuclear safety and security, nuclear detonation, and nuclear effects evaluation, criteria and requirements generated by Government Agencies shall be negotiated to mutual agreement.

   b. Employment of Non-Government Contractors to Satisfy Government Criteria

      Contractors employed by the Program Manager shall satisfy criteria and requirements generated by Government Agencies, which criteria may include a requirement for technical direction by Government Agencies over certain activities associated with safety and the nuclear explosive system or its support.

   c. Criteria, Forecasts, and Requirements Channels

      Government Agencies shall provide all Government Agencies' engineering, logistic, security and safety criteria, forecasts, and requirements to a single interface organization designated by the Contracting Officer for transmission to the Program Manager. All communications from the Program Manager to Government Agencies concerning criteria, forecasts, requirements and design drawings, as well as substitution, rejection, acceptance and/or modification thereof shall be

through this interface organization. This does not prohibit informal communication directly between technical personnel of Government Agencies or their contractors and the Program Manager.

d. Engineering and Services

Program Manager shall fund for and provide in accordance with Government Agencies' criteria and requirements the following:

1) Engineering:

Engineering for surface and underground facilities and services except R-PS-2.

2) Preliminary Services:

a) Topographical and other field surveys, including preparation of maps and drawings.

b) Preliminary studies and preliminary sketches, layout plans, outline specifications and reports showing features and characteristics of any design proposed to meet Government Agencies' criteria.

3) Design Services:

a) Design of construction projects, after approval by Government Agencies of critical preliminary plans, drawings and specifications.

b) Prepare, revise and furnish construction drawings and specifications.

4) Supervision and Inspection:

a) Inspect construction to assure adherence to approved drawings and specifications.

b) Inspect construction workmanship and materials, and equipment, including such field or laboratory tests of these items as may be required and report to Government Agencies as to their conformity or nonconformity to the approved drawings and specifications.

e. Inspection of Facilities and Logistical Services

Government Agencies shall fund for and provide, in conjunction with the Program Manager, necessary on-site inspection of the critical services or facilities provided by the Program Manager.

f. Acceptance of Facilities, Logistic Support and Data

Government Agencies shall provide and fund for the acceptance of support and facilities provided by the Program Manager in accordance with Government Agencies' furnished criteria. Acceptability and adequacy of the following shall be determined solely by Government Agencies:

1) Plans, procedures and practices related to industrial, fire, medical, and personnel safety involving Government employees, Government contractors' employees, or Government equipment or data. The industrial safety standards and practices established by the Commission shall be utilized as criteria.

2) Plans, procedures, and practices of implementing organizations in connection with nuclear safety.

3) Plans, procedures, and practices of implementing organizations related to the nuclear explosive and its associated systems, including emplacement, stemming, mechanical and electrical systems, support, power generation, cabling, surface structures, access roadways, security and recording diagnostic systems and their support.

4) Drilling of pre- and post-detonation hole (s), including their construction, stemming, re-entry closure, and protection.

5) Operational capability of communication systems relating to the transmission of operational reports.

6) Relability of data provided for the use of Government Agencies in their evaluation regarding safety of the nuclear detonation, effects of nuclear detonation and the safety actions required pre- and post-nuclear detonation.

Government Agencies shall be solely responsible for all such facilities, logistic support and data upon acceptance of same by Government Agencies.

g. Distribution of Documents

Whenever in this Project Definition Plan Program Manager is obligated to provide plans, maps, drawings, specifications, reports, etc., Program Manager shall provide seven (7) copies, one of which is a reproducible copy, thereof, to the Contracting Officer.

2. Phase I - Site Confirmation and Experimental Plan Development

a. The Government Agencies shall fund for and provide in accordance with this Project Definition Plan, the following:

1) Technical participation in the formulation of criteria, modifications thereto, and evaluation of data sufficient for the Government Agencies to determine the acceptability of a proposed Site Area or Site Areas for the Project Rulison. (NVOO, LASL, Department)

2) Preparation of plans, forecasts, requirements and/or criteria for nuclear safety, nuclear detonation and effects evaluation for all Phases; such technical direction for Phase I work as may be required to insure conformity to established criteria and acceptability. (LASL, NVOO)

3) Geologic, hydrologic, core-analyses, rock properties, and fluid analyses data that may be suitable or applicable as available from the Government Agencies. (USGS, BuMines)

4) Technical participation by the Government in the development of the experimental plans for all Phases other than that provided for in subparagraph 2) above. (BuMines, AEC)

5) The Government Agencies' data on a continuing basis as applicable. (LASL, ESSA/ARL, ESSA/Weather Bureau, USGS, BuMines, USPHS, NVOO)

6) Information in possession of Government Agencies with respect to ownership of land and rights that may be affected, and site, topographic, and other maps in possession of the Government Agencies to the extent not privileged.

7) Ground motion predictions, containment analyses, and preliminary predictions of structural response. (ERC, Blume Ass., LASL)

8) Hydrologic data and calculations. (USGS)

9) Reduction of weather data supplied by the Program Manager. (ESSA/ARL)

b. Program Manager shall fund for and provide, in accordance with this Project Definition Plan, the following:

1) Drill and complete necessary well in accordance with the specifications.

2) Geologic and hydrologic studies, core-analyses, rock properties, and fluid analyses, geophysical logs, and hydrologic tests, except such data, logs, tests, and analytical results as may be provided by Government Agencies at Government Agencies' expense.

3) Fluid production and test equipment, including packers, flow meters, recorders, bottom hole instruments.

4) Mechanical weather station data acquisition.

5) Logistic support, local transportation, communications, road construction, road maintenance, and general Project Site maintenance and operation.

6) a) Information reflecting surface and subsurface ownership and use status and other pertinent data with respect to non-federal lands which might be affected by the experiment.

b) Securing of such agreements, consents, or waivers which the Parties may agree are necessary and reasonably obtainable with respect to private rights in all lands, including mineral rights, which may be affected by the experiment.

c) Securing reasonably obtainable rights for the Parties to enter upon and use non-federal land as required.

7) Data required, but not available from or provided by Government Agencies, pertaining to environmental, technical, safety and cultural conditions, adequate to identify and evaluate the on- and off-site safety conditions, and to accept, reject, or accept with qualification, the Project Site.

8) Site, topographic, and other maps, required for project planning to the extent not provided by Government Agencies.

9) Analyses of cores cut in pre-shot wells and analyses of fluids therefrom as desired by Program Manager.

3. Phase II - Nuclear Operations

a. Government Agencies shall fund for and provide, in accordance with this Project Definition Plan, the following:

1) Technical participation in the development of criteria for and evaluation of drill holes, including sampling and logging activities therein. (LASL, BuMines, NVOO)

2) Criteria and requirements for facility engineering and construction, security facilities, communications and logistic support relating to safety and the nuclear explosive system, cable and associated hardware. (LASL, NVOO)

3) Criteria and requirements for industrial and nuclear on- and off-site safety, and nuclear operational and security programs, including instrumentation, personnel, logistic support. (LASL, NVOO)

4) The nuclear explosive system, including the explosive, diagnostic system, delivery, custody, and assembly of the explosive system and components, emplacement, arming and detonation, including technical direction and technical services associated therewith. (LASL)

5) Operational direction, management and control of the on- and off-site safety and security programs. (NVOO)

6) Support of the Public Information Office and Public Visitor Programs to include participation, local and other transportation and services as may be required for those visitors invited by the Government Agencies. (NVOO)

7) Weather observations, predictions, and fallout pattern calculations. (ESSA/ARL)

8) Equipment as follows:

   a) Communications equipment for low-band net, including base stations, mobile stations, transmitter and repeaters, (NVOO)

   b) Seismometers and long-term recorders. (C&GS)

   c) Nuclear explosive-related, including Arming and Firing, diagnostics and the W-3 trailer. (LASL)

   d) RAMS and air samplers plus their readout equipment. (NVOO)

   e) Security van and other security related necessities. (Wackenhut Services, Inc.)

   f) Radiological measurements trailer and associated equipment. (NVOO)

   g) Access Control Trailer and associated equipment. (NVOO)

   h) Ground Meteorological Device trailer and associated equipment and the balloon inflation van, the necessary pibal units, and powered wind sensors with associated power supplies and readout equipment. (ESSA/ARL)

b. The Program Manager shall fund for and provide, in accordance with this Project Definition Plan, the following:

1) Drilling, loading, stemming, grouting and logging of pre-shot wells.

2) Construction of access roads, cleared and graded areas, the observer area, trailer pads, control point, cable ways, electrical power supply and distribution system, fencing and guardhouses, and other required on- and off-site project facilities.

3) Procurement and installation of communication facilities except those items identified as government-furnished equipment.

4) Maintenance of Project Site facilities.

5) Procurement of cable, cable handling equipment and associated hardware.

6) Laying of cable and trailer hook-up.

7) Emplacement support for the nuclear explosive, associated instrumentation and stemming in the emplacement hole.

8) Operational and logistic services in support of Government Agencies' operational systems relating to control of the Project Site prior to, during, and subsequent to, detonation, including aircraft, roadblock controls, evacuation and Project Site control. (Wackenhut, USPHS and others)

9) Support of the Public Information Office and Public Visitor Programs to include participation, local and other transportation and services as may be required for those visitors invited by the Program Manager.

10) Effects Safety programs, except associated equipment, including radiological safety support (on- and off-site), meteorological data acquisition, structural response studies, seismic measurements, and air sampling program at detonation time. (USPHS, ESSA/ARL, C&GS, Blume Ass., USGS, BuMines)

11) Transportation for necessary project-related personnel between local living quarters and Project Site and general areas related thereto. Transportation is to be GSA rentals.

12) Installation and support of government-furnished trailers.

13) Industrial safety.

14) Services of "Q" cleared guards. (Wackenhut)

4. Phase III - Post-Shot Investigations

a. Government Agencies shall fund for and provide, in accordance with this Project Definition Plan, the following:

1) Technical guidance of the post-shot re-entry drilling program. (LASL, NVOO)

2) Laboratory analysis to the extent such may be performed for the purpose of verifying explosive performance. (LASL)

3) Criteria and requirements for nuclear on- and off-site safety and nuclear operational and security programs, with respect to personnel, instrumentation, logistic support and post-shot data. (NVOO)

4) Technical participation in the evaluation of drill holes and review of technical programs, including fracture studies and radioactivity, jointly with the Program Manager. (BuMines, AEC)

5) Technical participation in the development of criteria for, and evaluation of nuclear effects in coordination with the Program Manager. (NVOO)

6) Criteria, drilling, coring, logging, completion, associated construction, radiological safety, testing and evaluation of post-shot drill hole (R-PS-2). (This drill hole is specifically included at the request of the Department.) (BuMines)

7) Down hole sampling and analyses, equipment analyses, and operating sampling and analytical personnel, if required by Government Agencies. (NVOO subcontractor)

8) Equipment as follows:

a) Gas sampling and tritium monitoring equipment. (BuMines)

b) Gas sample analyses. (BuMines/USPHS)

c) Radiological safety equipment and trailers. (NVOO)

d) Recirculation unit. (If required, AEC)

9) Operator for any required recirculation Unit. (NVOO)

10) Information required to complete the project and prepare the final report. (All participants)

b. The Program Manager shall fund for and provide, in accordance with this Project Definition Plan, the following:

1) Fluid sampling and analyses except as may be provided by the Government Agencies at Government Agencies expense.

2) Drilling, logging and completion and testing of the post-shot investigation well (R-PS-1) except those that may be provided by Government Agencies at Government Agencies' expense.

3) Transportation for necessary project-related personnel between local living quarters and Project Site and general areas related thereto.

4) Installation and support of government-furnished trailers.

5) Supervision of the drilling, scheduling and testing of R-PS-2.

6) Fence the emplacement hole.

7) Necessary security and safety support.

8) Nuclear stimulated model of the reservoir.

9) Economic evaluation.

10) Final report.

C. TECHNICAL INFORMATION AND REPORTING

1. Reports and Documents

a. Field Reports

The Project Director shall prepare, during Phase II, a Field Report every 2 weeks on construction, drilling, status of critical procurement, and other related project activities, including scheduling, based on information provided by all project participants.

b. Technical Reports

Technical Reports describing specific aspects of work, experimental results, and analytical and interpretive reports on data collected shall be prepared as deemed timely and appropriate by the technical personnel responsible for such aspects.

c. Reports Pertaining to Atomic Energy

It is recognized that any Field or Technical Report concerned with atomic energy, prepared and distributed as provided for in items a. and b. above, may be used by the Commission for any purpose in fulfillment of the obligations and requirements of the Atomic Energy Act, including dissemination and publication.

d. Safety, Health, and Medical Reports

Safety, health, and medical reports shall be prepared once a month by the Program Manager, or in individual cases as deemed necessary by the Program Manager or the Contracting Officer, and distributed to the Contracting Officer and the involved participants. The Contracting Officer shall have the right to use the same at his discretion in fulfillment of any health and safety requirements of the Atomic Energy Act or Regulations thereunder. Such reports shall be used by the Government and the involved participants and be subject to the limitations and restrictions as respects general medical reports.

e. Final Reports

A Final Report, based on information or supplemental reports on both the Technical and Safety programs, provided by project participants shall be assembled and distributed by the Program Manager upon completion of the project. The Final Report is to be distributed to the project participants and may be disseminated and published as desired by them, subject to security and patent review.

f. Open File

Raw data from the experiment shall be provided to the Plowshare open files. Interpretive data shall be provided to the open file on agreement by the participants.

2. Proprietary Information

The Program Manager, when delivering any information to the Contracting Officer, shall, if the information includes any secret processes, technical information, or know-how which is "proprietary" to the Program Manager or Austral, note the same on the cover of the document and identify the specific "proprietary information," in which event the Contracting Officer shall use his best efforts to respect the proprietary information.

D. PUBLIC INFORMATION AND OBSERVER PLAN

This plan establishes a Joint Office of Information (JOI) to carry out public information activities for Project Rulison. The JOI will serve as the primary point of contact between the operational organization, official observers, and the public. Until such time as this activity moves to the project area and an actual office is established, all Rulison participants will coordinate activities from their home offices.

1. Application

   a. This plan applies to all Project Rulison participants, and all contractors and subcontractors of participants.

   b. This plan becomes effective when approved by the principal project participants and will remain in effect until Project Rulison post-shot drilling is concluded.

2. Policy

   a. The Project Rulison Public Information Program will be conducted under an open information policy. An open policy is required to create a climate of public acceptance and awareness of the value of the use of nuclear explosives for peaceful purposes and, particularly, their application to the stumulation of production and recovery of natural gas.

   b. Information on Rulison which previously has been approved and issued may be reissued or used again by any participant.

3. Objectives

   The objectives of the Public Information Program are:

   a. To keep the public, all interested individuals and groups, project participants, and other associated organizations and individuals, fully informed about preparations for the conduct and results of Project Rulison.

b. To assure that information actions taken are consistent with the demands for safety, national security, proprietary information, operational requirements, and the policies jointly agreed to by the principal project participants.

c. To make appropriate contacts and provide these contacts with information to minimize public misunderstanding and/or concern.

d. To provide for timely release of official information concerning the Rulison Project.

c. To provide information and assistance to all official visitors, including news media representatives, and to make reasonable and timely arrangements for them to visit the Rulison site before and after the detonation, except when safety, security, or operational considerations make such visits impractical. Arrangements will be made to transport official observers to the observer area to view the event on D-Day. Figure V. 1 is a PERT type diagram showing the observer plan on D-1 and D-Day.

4. Major Tasks

The major tasks of the JOI are:

a. To maintain effective community and regional relations, including the conduct of public meetings in the project area with local officials, civic and business groups, and local residents during the Rulison Project.

b. To issue information -- in written, oral, or pictorial form as appropriate -- regarding:

1) Construction progress and operational methods.

2) Safety precautions.

3) Schedule.

4) Visitor Arrangements.

5) Post-shot evaluation.

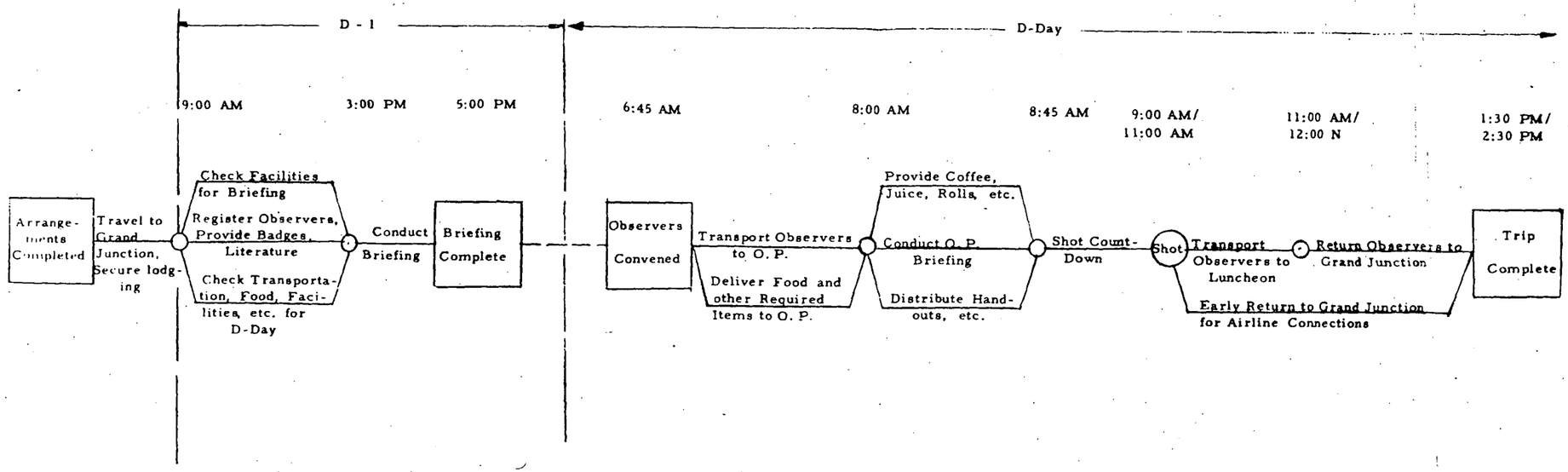


Figure V. 1
Observer Plan

c. To be responsible for developing and executing appropriate official and news media observer programs.

1) Invitations to observe the execution of Project Rulison will be extended, as appropriate, by each participating organization after coordination by the JOI.

2) Official and news media observer programs will include briefings before and after execution of the event, and provisions for providing news media representatives with appropriate information and observation of the event itself.

5. Organization

a. The JOI will be established by the major participants acting in a mutual fashion, and during the nuclear operation phase it will be responsible to the DONO.

b. During the nuclear operation phase, the JOI will be directed by an AEC employee. A CER employee will be associate director. Professionally oriented public information or public relations staff members will be designated as appropriate.

c. The JOI will function as a joint unit regardless of the geographic location of the director and staff members. When appropriate, a few weeks in advance of the scheduled nuclear detonation, a JOI staff will begin functioning in the Rulison area.

6. Organizational Responsibilities

a. Normally, information actions will be originated in the JOI and coordinated by that office within the project organization and participating organizations as judgment dictates.

b. The JOI will be informed of any public information action taken by a participant on Project Rulison.

c. Information actions in all cases will take into account any proprietary interest of any participant.

d. Each organization will have primary responsibility for originating information issuances related to its particular role and capability -- CER and USBM for gas reservoir information, the NVOO for nuclear detonation effects, etc. In this regard, the AEC will have sole responsibility for authorization of public information action related to the nuclear operations and nuclear safety aspects of Project Rulison.

e. Each staff member will keep all other staff members fully and currently informed of significant or interesting developments regarding Project Rulison. The Director will inform the staff of current status and projected activities.

f. Industrial or other serious accidents involving injury to one or more persons or destruction of property at or near the Rulison site will be reported promptly to the JOI. The JOI will determine if an announcement is required.

7. Major Item Schedule

a.	Issue Project Visitor Plan	D - 7 weeks
b.	Mail invitations to prospective visitors	D - 6 weeks
c.	Hold briefings for visitors	D - 1 day
d.	Post-shot visitor support	D -1 day to D + 6 months

E. ECONOMIC PLAN

The purpose of the Economic Plan is to accumulate the costs incurred and to assess these costs in conjunction with other pertinent data, such as those described in the Technical & Safety Plans and to evaluate the potential for future commercial development using nuclear stimulation techniques.

In order to assure that appropriate costs are being used in the evaluation, every effort will be made to reduce costs wherever practical. This assumes that unnecessary activities have been removed, or will be as the operation develops, and that site population will be minimized.

1. Cost Collection

To collect costs, each task will be assigned a four digit number. The first digit on Project Rulison will be "4." The second digit will be broken out by:

1 = Phase I
2 = Phase II
3 = Phase III
4 = Common or General

The last two digits have been arbitrarily assigned beginning with 01. A sample of the numbers and their associated tasks are as follows; greater detail can be found on the task sheets in Section VIII.

4-1-01 Phase I - Road and Mat Construction and Maintenance
4-2-01 Drilling and Complete R-E
4-3-01 Drill R-PS-1
4-4-01 Project Management

Each of these tasks will be divided into 6 categories:

Labor
Travel
Equipment
Construction
Materials
Services

The estimated costs for each task is itemized as far as practical on task sheets in Section VIII.

All costs will be reported with necessary comments for a meaningful interpretation.

2. Evaluation

Upon completion of the project, an evaluation and assignment will be made of those costs which would be applicable to future production activities. These, along with the other data, e.g., the post-shot effects model of the well, yield escalation possibilities, safety, etc., will be evaluated. Other factors have an impact, but are either unavailable or not within the scope of this project.

F. LAND STATUS

The Rulison Unit covers approximately 50,000 acres of land and consists of approximately 300 oil and gas leases owned by Austral and acquired from the United States of America as to lands which it owns, and from a large number of individuals and corporations as to fee lands included in the Unit. Approximately 50.2% of the land included in the Rulison Unit is owned by the United States with the remainder being owned by approximately 260 other land owners. The Project Site is located on private lands and a copy of the oil and gas lease covering such Site, as well as a copy of the two lease forms used in leasing lands owned by the United States, has been furnished to the AEC-NVOO.

The rights which Austral has to enter upon the land which is included in the Rulison Unit, to conduct seismic or other exploratory operations thereon, to drill exploratory and development wells and to produce, store, transport, treat and market any oil and gas discovered thereon, are derived from such oil and gas leases and from the Rulison Unit Agreement entered into by Austral (and Union Oil Company of California, as to a tract of 920 acres) and the owners of the lands involved, including the United States.

It should be noted that the leases, both Federal and private, are for primary terms of five or ten years which terminate at various dates, unless such leases are maintained in force after the expiration of their primary terms by production of oil or gas or by continued drilling or other operations. Any grants of use which Austral may make to CER Geonuclear Corporation and any permission which CER may grant to the Government to use and control the Project Site arise only from rights acquired by Austral pursuant to such oil and gas leases and Rulison Unit Agreement.

VI. LOGISTICS AND SUPPORT PLAN

The purpose of the Logistics and Support Plan is to identify and forecast major support items required for the tasks described in this Project Definition Plan. These forecasts have been coordinated and agreed upon by the participants and any changes based on further detailed planning is not expected to vary the total cost by more than 15%. If a major programmatic change is made, or in the unlikely event that venting or other such safety problems occur, then the support requirements will change as required.

Support will be provided only for necessary project personnel and includes administrative, transportation, communications, and field support at or in the vicinity of the site. Figure VI. 1 shows Project Population.

A. ADMINISTRATIVE SUPPORT

1. Office Space in Town

Use of office space in a suitable base town is planned. If practical, the office space will be rented or if insufficient space is available, office trailers will be obtained.

The assigned office space indicated in Figure VI. 2 includes that necessary for secretaries and/or clerks, as well as filing cabinets, desks and normal office furniture. Utilities, janitorial service, parking area, and communications will be supplied.

2. Miscellaneous

a. Materials

Paper, pencils, and general office supplies will be available in the base town as required.

b. Reproduction Services

A desk-type copier will be available in the base town. Other reproduction requirements will have to be fulfilled elsewhere.

PERSONNEL	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
AEC DONO												1	1																		
Advisory Panel												4	4																		
Washington Representatives												2	2																		
AEC Air Ops Controller												1	1																		
AEC Dep TM/Ops											1	1	1	1																	
AEC Operations Officer									1	1	1	1	1	1																	
Chief-Ops Coordination									1	1	1	1	1	1																	
Ops Coordination									3	3	3	3	3	3																	
AEC - E&L					1	1	1	1	2	2	2	2	2	2																	
AEC - Security									1	1	1	1	1	1																	
AEC - Safety Effects										1	1	2	2	1							1	1	1	1	1	1	1				
On-Site Rad Safe									3	3	3	7	7	7	3	2				4	5	5	4	4	4	4	4				
Public Health & Safety		1		1	1	1		1	2	3	3	25	25	23																	
Meteorological									2	2	6	10	10	10																	
Ground Motion*	2	4	4					2	2		9	19	19	19	4	4	4	4	1												
Industrial Safety					1	1	1	1	2	2	2	2	2	.1	1																
Security Personnel										12	12	12	12																		
LASL						11	11	11	18	18	14	22	22	13	2						2	2	2	2	2	2	2				
Hydrology and Geology		2								1	1			1																	
PM		1	2	2	2	6	6	6	8	9	10	11	11	10	6	4	1		1	3	4	3	4	3	3	3	1	1	1	1	1
Total Population	2	8	6	3	5	20	19	22	45	59	70	127	127	95	17	10	5		2	7	12	11	11	10	10	10	11	1	1	1	1

*Ground Motion estimates that 4 people will be needed through D+2 months.

Figure VI.1
Project Population

Base Town Office Space Requirement	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
DONO							2	2	2	2	2	2	2	2																	
Public Health & Safety										1	1	1	1	1																	
Meteorology									5	5	5	5	5	5																	
PM			2	2	2	2	2	4	4	10	10	10	10	10	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
Ground Motion									2	2	2	2	2	2																	
AEC - E&L					2	2	2	2	2	2	2	2	2	2																	
Total Office Space (In hundreds of sq ft)			2	2	4	4	6	8	15	22	22	22	22	22	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1

Figure VI. 2
Base Town Office Space Requirement

c. Furniture

Desks, chairs, typewriters, filing cabinets, wastebaskets, desk lamps, and tables will be available.

d. Drafting

One drafting table, complete with drafting machine, will be available in the PM's office space in the base town. This table will be available for miscellaneous drafting requirements. No draftsmen will be available.

B. TRANSPORTATION

The vehicles available for Project Rulison are shown in Figure VI. 3. These vehicles are for necessary project personnel and will be obtained from commercial rental organizations and/or the U. S. Government for government employees and its subcontractors. The distribution and maintenance of vehicles will be supplied as well as fuel, oil, and lubricants.

C. COMMUNICATIONS

1. Telephones

a. On-Site Telephones

There will be one outside hardwire telephone line from the CP to the exchange. There will be 1 instrument in the AEC-OCC trailer and 1 instrument at both the Security Headquarters trailer and Security van at SGZ. To supplement the hardwire telephone line, a radio telephone system will be utilized.

In addition, an on-site telephone communication system will be established using field phones:

AEC Trailer to ARL/LV Trailer
AEC Trailer to Security Van
AEC Trailer to LASL OD Trailer
AEC Trailer to PM Trailer
AEC Trailer to LASL A&F Trailer (2 lines - 4 phones)
LASL Trailer to PM Trailer
LASL A&F Trailer to LASL Wellhead Shack (Hot Line)

VECHILES (All types)	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
AEC DONO Advisory Panel																															
Washington Reps. Air Ops Controller									3	3	4	7	7	4																	
AEC Dep TM/Ops																															
AEC Operations Officer																															
Chief Ops Coord. Ops Coordination																															
AEC - E&L					1	1	1	1	2	2	2	2	2	2																	
AEC - Security									1	1	1	1	1	1																	
AEC Safety Effects										1	1	2	2	2	1						1	1	1	1	1	1	1				
On-Site Rad Safe									2	2	2	4	4	4	2	1				2	3	3	3	2	2	2	2				
Public Health & Safety		1		1	1	1		1	2	3	3	24	24	23																	
Meteorological									3	3	5	5	5	5																	
Ground Motion	1	2	2					1	1	5	5	17	17	17	2	2	2	2	1												
Industrial Safety*					1	1	1	1	1	1	1	1	1	1	1																
Security Personnel										4	4	5	5																		
LASL						7	7	7	11	11	10	14	14	11	2						2	2	2	2	2	2	2				
Hydrology & Geology		2								1	1			1																	
PM		1	2	2	2	3	3	3	3	4	4	5	5	4	3	3	1		1	2	2	2	2	2	2	2	2	1	1	1	1
Total Vehicles (All types)	1	6	4	3	5	13	12	14	29	41	43	87	87	75	11	6	3	2	2	4	8	8	8	7	7	7	7	1	1	1	1

*Ambulance is furnished for industrial safety

Figure VI. 3
Vehicle Requirements

LASL telephone net will link the LASL W-3, A&F, and Operations Director trailers at the CP with the LASL J-1, J-6, and the Wellhead Shack at SGZ.

b. Off-Site Telephones

Two lines will be needed at the office space in town:

DONO - 2 instruments
PM - 2 instruments

2. Radios

The total radio requirement is shown in Table VI. 4A & B. Radio communication will be operational from D-6 weeks through D+1 week. Installation and maintenance of all equipment will be provided.

3. Public Address System

Public address systems will be installed at both the CP and observer area so that the countdown will be available to personnel in those areas.

D. FIELD SUPPORT

1. Trailers

The trailer support is shown in Figure VI. 5. Transportation for the trailers to and from the Rulison Site, as well as the necessary cribbing, stairways, connecting walkways, and maintenance, will be provided. During D+1 week, all trailers will be returned to home base or SGZ.

a. There will be 14 trailers located at the CP at event time. This includes the security trailer or van, LASL J-1 and J-6 trailers and the First Aid trailer withdrawn from SGZ for the event.

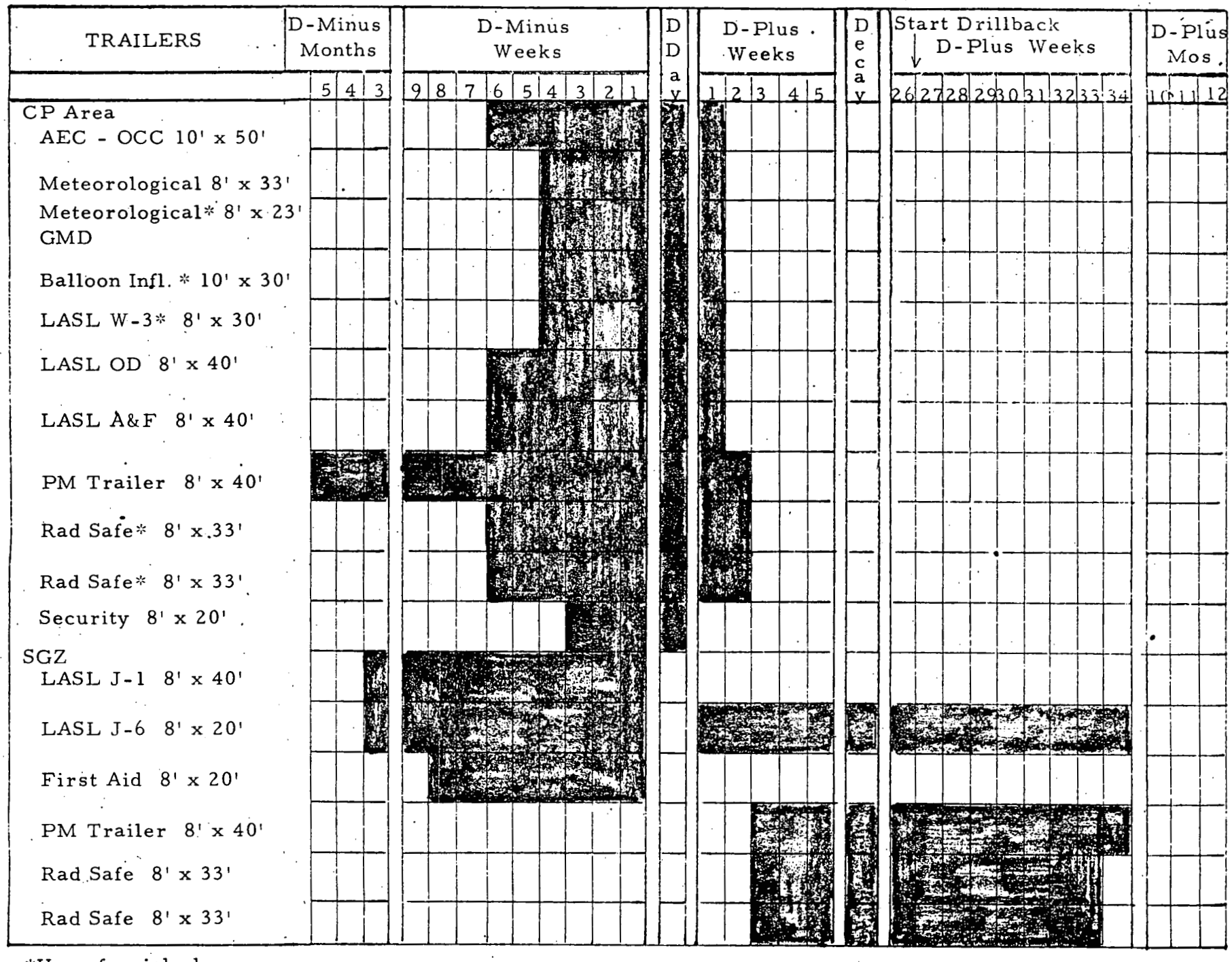
b. At SGZ, for the normal pre-shot activities, there will be 2 LASL trailers, the First Aid trailer, and the Security trailer or van that provides security to the Wellhead Shack.

MOBILE RADIOS	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
AEC DONO Advisory Panel																															
Washington Reps.																															
Air Ops Controller									3	3	4	6	6	4																	
AEC Dep TM/Ops																															
AEC Operations Officer																															
Chief, Ops Coordination																															
Ops Coordination																															
AEC - E&L									2	2	2	2	2	2																	
AEC Security									1	1	1	1	1	1																	
AEC Safety Effects									N	O	N	E																			
On-Site Rad Safe									2	2	2	3	3	3																	
Public Health & Safety										1	3	22	22	22																	
Meteorological									3	3	5	5	5	5																	
Ground Motion												2	2	2																	
Industrial Safety							1	1	1	1	1	1	1	1																	
Security										4	4	5	5	4																	
LASL									2	2	2	2	2																		
Hydrology & Geology									N	O	N	E																			
PM							2	2	2	2	2	2	2	2																	
Aircraft (3)											3	3	3																		
Total Mobile Radios							3	3	16	21	29	54	54	46																	

Figure VI. 4A
Mobile Radio Requirements

BASE STATION RADIOS	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
AEC DONO																															
Advisory Panel																															
Washington Reps.																															
Air Ops Controller							2	2	2	2	2	2	2	2																	
AEC Dep TM/Ops																															
AEC Operations Officer																															
Chief, Ops Coordination																															
Ops Coordination																															
AEC - E&L								N	O	N	E																				
AEC Security								U	S	E		O	C C																		
AEC Safety Effects								N	O	N	E																				
On-Site Rad Safe								N	O	N	E																				
Public Health & Safety								N	O	N	E																				
Meteorological									1	1	1	1	1	1																	
Ground Motion									1	1	1	1	1	1																	
Industrial Safety								N	O	N	E																				
Security										2	2	2	2	2																	
LASL									1	1	1	1	1																		
Hydrology & Geology								N	O	N	E																				
PM							2	2	2	2	2	2	2	2																	
Total Base Station Radios							4	4	7	9	9	9	9	8																	

Figure VI. 4B
Base Station Radio Requirement



*User furnished

Figure VI. 5

2. Power

Electrical power to the Rulison Site will be provided by single phase commercial power. Only in emergencies or other isolated cases will generators be used. Power requirements planned for are as follows:

a. CP Area

	Utility Power	Instrument Power
ARL/LV Balloon Inflation Trailer	0	
ARL/LV Forecast Trailer	7KW	
AEC-OCC Trailer	15KW	
LASL OD Dir Trailer	12KW	
LASL A&F Trailer	10KW	10KW
A&F Trailer Air Conditioning	7.5KW	
LASL W-3 Trailer	20KW	20KW
PM Trailer	12KW	
Security Trailer	10KW	
Radiological Safety Trailers	24KW	
Lighting Misc.	10KW	
	127.5KW	30KW

b. SGZ Pre-Shot

LASL J-1 Trailer	12KW	
LASL J-6 Trailer	9KW	
Wellhead Shack	13KW	3KW
Security Van	5KW	
Security Emergency Generator	10KW	
First Aid Trailer	5KW	
Lighting, Misc.	10KW	
	64KW	3KW

c. SGZ Post-Shot

PM Trailer	12KW
Radiological Safety Trailers	24KW
	36KW

3. Miscellaneous Field Support

Air conditioners for the LASL A&F Trailer and Wellhead Shack will be supplied.

An emergency vehicle fuel supply will be located at the CP area.

E. DONO SUPPORT

1. DONO and Staff Support

The major support items for the DONO and staff are shown in Figure VI. 6. A, B, C, and D.

A clerk-typist will be available from the PM to support the DONO.

2. On-Site Radiological Support

The major support items for on-site radiological safety are shown in Figure VI. 7.

3. Public Health and Safety Support

The major support items for Public Health and Safety are shown in Figure VI. 8.

4. Meteorological Support

Support for the Meteorological effort is shown in Figure VI. 9.

5. Ground Motion and Structural Response Support

Support for the Ground Motion and Structural Response is shown in Figure VI. 10.

AEC DONO	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks										D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
PERSONNEL																															
AEC Test Manager												1	1																		
Advisory Panel (4)												4	4																		
Washington Reps (2)												2	2																		
Air Ops Controller												1	1																		
AEC Dep. TM/Operations											1	1	1	1																	
AEC Operations Officer									1	1	1	1	1	1																	
Chief Operations Coord									1	1	1	1	1	1																	
Operations Coord (3)									3	3	3	3	3	3																	
Total Personnel									5	5	6	14	14	6																	
Vehicles - Sedan									1	1	2	5	5	2																	
4 x 2 Pickup									2	2	2	2	2	2																	
Total Vehicles									3	3	4	7	7	4																	
Mobile Radios									3	3	4	6	6	4																	
Base Station Radios									3	3	3	4	4	3																	
Telephone - Outside Line									3	3	4	5	5	3																	
Telephone - On-Site (Field Phones)									2	3	3	5	5	1																	
Office Space - On-Site (OCC Trailer)									x	x	x	x	x	x																	
Office Space - Off-Site (Base Town -X100SF)									2	2	2	2	2	2																	

Figure VI. 6A

AEC E&L Division	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel					1	1	1	1	2	2	2	2	2	2																	
Total Personnel					1	1	1	1	2	2	2	2	2	2																	
Vehicles - Sedan									1	1	1	1	1	1																	
4 x 2 Pickup								1	1	1	1	1	1	1																	
4 x 4 Pickup					1	1	1																								
Total Vehicles					1	1	1	1	2	2	2	2	2	2																	
Mobile Radios									2	2	2	2	2	2																	
Base Station Radios																															
Telephone - Outside Line (Access)																															
Telephone - On-Site (Access)																															
Office Space - On-Site (PM Trailer)						←								→																	
Office Space - Off-Site (1 Desk, 150) (In hundreds sq ft)						←								→																	

Figure VI. 6B
AEC - DONO Support

AEC - SECURITY	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel									1	1	1	1	1	1																	
Total Personnel									1	1	1	1	1	1																	
Vehicles - Sedan									1	1	1	1	1	1																	
Total Vehicles									1	1	1	1	1	1																	
Mobile Radios									1	1	1	1	1	1																	
Base Station Radios (OCC)									1	1	1	1	1	1																	
Telephone - Outside Line																															
Telephone - On-Site (OCC)									1	1	1	1	1	1																	
Office Space - On-Site (OCC)									←					→																	
Office Space - Off-Site																															

Figure VI. 6C
AEC - DONO Support

AEC Safety Effects Division	D-Minus Months			D-Minus Weeks									DDay	D-Plus Weeks					Decay	Start Drillback D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel										1	1	2	2	2	1						1	1	1	1	1	1	1				
Total Personnel										1	1	2	2	2	1																
Vehicles - Sedan																														
4 x 2 Pickup										1	1	2	2	2	1						1	1	1	1	1	1	1				
Total Vehicles										1	1	2	2	2	1																

Figure VI. 6D
AEC - DONO Support

ON-SITE RADSAFE.	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Elect. Engr.									1	1	1	1	1	1																	
Elect. Tech.									2	2	2	2	2	2																	
Monitors												3	3	3	2	2				3	4	4	3	3	3	3	3				
Health Physicist												1	1	1	1						1	1	1	1	1	1	1				
Total Personnel									3	3	3	7	7	7	3	2				3	5	5	4	4	4	4	4				
Sedans W/O Radio												1	1	1	1						1	1	1								
Sedan - Radio												1	1	1																	
Pickup W/O Radio																				2	2	2	2	2	2	2	2				
4 x 4 PU W/O Radio															1	1															
4 x 4 PU - Radio									2	2	2	2	2	2																	
Total Vehicles									2	2	2	4	4	4	2	1				2	3	3	3	2	2	2	2				
Mobile Radios									2	2	2	3	3	3																	
Trailers On-Site																															
8' x 33'							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
8' x 33'							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				

Figure VI. 7
On-Site Radiological Safety Support

Public Health and Safety Support	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D e c a y	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Casual				1	1	1				1	1	3	3	1																	
Monitors								1	2	2	2	20	20	20																	
Supervisors/Coord.												2	2	2																	
Ecologist		1																													
Total Personnel		1		1	1	1		1	2	3	3	25	25	23																	
Sedans W/O Radio		1		1	1							2	2	2																	
Sedans - Radio										1	1	8	8	7																	
Pickup W/O Radio								1	2	2																					
4 x 4 with Radio											2	4	4	4																	
Carryall With Radio													10	10																	
Total Vehicles		1		1	1			1	2	3	3	24	24	23																	
Mobile Radios										1	3	22	22	22																	
Office Space Town 10' x 10'										1	1	1	1	1																	
Site (Share with AEC-OCC) (In hundreds sq ft)																															

Figure VI..8
Public Health and Safety Support

Meteorological Support	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Meteorologist											2	4	4	4																	
Met. Tech.									1	1	3	5	5	5																	
Elect. Tech.									1	1	1	1	1	1																	
Total Personnel									2	2	6	10	10	10																	
Sedans W/O Radio																															
Sedans - Radio											2	2	2	2																	
Pickup - Radio									3	3	3	3	3	3																	
Total Vehicles									3	3	5	5	5	5																	
Mobile Radios									3	3	5	5	5	5																	
Base Stations									1	1	1	1	1	1																	
Office Space																															
Town 10' x 50'									1	1	1	1	1	1																	
Site 8' x 30'									1	1	1	1	1	1																	
Telephone-outside line (Access)									1	1	1	1	1	1																	

(In hundreds sq ft)

Figure VI. 9
Meteorological Support

Ground Motion & Structures	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Geophysicist	1								1	1	1	1	1	1																	
Geologist	1																														
Technician										5	5	5	5	5																	
Mining Engineers								2	2			2	2	2																	
*Civil/Mech. Engineers		2	2								2	10	10	10	2	2	2	2	1												
*Architect		2	2								2	2	2	2	2	2	2	2													
Total Personnel	2	4	4					2	2		9	19	19	19	4	4	4	4	1												
4 x 4 Pickup W/O Radio								1	1																						
Sedans	1	2	2								2	12	12	12	2	2	2	2	1												
4 x 4 Pickup - Radio												2	2	2																	
4 x 2 Pickup											3	3	3	3																	
Total Vehicles*	1	2	2					1	1	5	5	17	17	17	2	2	2	2	1												
Base Town Office Space (In hundreds of feet)									2	2	2	2	2	2																	

*Continues for D+2 months

Figure VI. 10
Ground Motion and Structural Response Support

6. Geological and Hydrological Support

Support for Geological and Hydrological studies is shown in Figure VI. 11.

7. Industrial Safety

Measures will be taken to assure the safety of personnel working in the Rulison area. Each organization will be individually responsible for monitoring its own operation to assure that safe and healthful working conditions are provided and maintained.

a. First Aid

An experienced first aid man and a trailer will be located at SGZ. The normal first aid supplies and telephone communication to town will be supplied. A radio-equipped ambulance with blankets, stretcher, and first aid supplies will be stationed beside the first aid trailer.

Items required to support the first aid facility are shown in Figure VI. 12.

b. Fire Protection

Hand operated fire extinguishers will be provided for the trailers and other test equipment locations. In addition, fire barrels with fire buckets will be provided at the CP and SGZ.

c. Sanitation

Chemical toilets and cool cans will be provided at the CP, Radiological Safety and SGZ areas. In addition, toilets will be provided for the observer area during the time of interest.

8. Security

The support requirements are shown in Figure VI. 13. It is assumed that the security contractor will be self-supporting in the way of guns, ammunition, classified repositories, clothing, red flashing lights, bullhorns, and other equipage.

Hydrology & Geology	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					D ecay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Hydrologist		1*								1	1			1																	
Geologist		1*																													
Total Personnel		2								1	1			1																	
Sedans w/o Radio		2*								1	1			1																	

*1 Week

Figure VI. 11
Geologic and Hydrologic Studies

First Aid Support	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
First Aid Man					1	1	1	1	2	2	2	2		1	1																
Ambulance W/O Radio					1	1									1															
Ambulance with Radio							1	1	1	1	1	1	1	1																	
Mobile Radio							1	1	1	1	1	1	1	1																	
First Aid Trailer					1	1	1	1	1	1	1	1	1	1	1																
Telephone - Outside Line (Access)					1	1	1	1	1	1	1	1	1	1	1																

Figure VI. 12
Industrial Safety, First Aid Support

Security	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Guards										12	12	12	12	12																	
Total Personnel										12	12	12	12	12																	
Vehicles																															
Sedan										2	2	2	2	2																	
4 x 2 Pickup										1	1	1	1	1																	
4 x 4 Pickup										1	1	1	1	1																	
Econo Van or Sm. Trailer Radio										1	1	1	1	1																	
Total Vehicles										5	5	5	5	5																	
Mobile Radios										4	4	4	5	4																	
Base Stations										2	2	2	2	2																	

Figure VI. 13
Security Support

a. Security Headquarters

Security headquarters will be established in a 8 x 20 ft trailer at the CP. A base station radio and a telephone extension to the hardwire telephone link will be furnished. In addition, a field phone system will link the security headquarters with the SGZ security van.

b. SGZ Security

A "Van" type vehicle will be used as a security post outside of the Wellhead Shack at SGZ. It will have a radio and a telephone for communication. Immediately prior to the time of the detonation the unit will be moved to the CP. As soon as the SGZ area is determined to be safe for re-entry, and all classified material has left the site, the security effort will be eliminated.

c. Security Desk - OCC

A desk will be placed in the OCC trailer for AEC Security. Telephone service to off-site and radio equipment will be shared with other AEC functions in OCC.

d. Fencing

If necessary, SGZ will be roped off during pre-shot activities and during D+1 week. For the post-shot activities, a six-foot hogwire fence topped with barbed wire will be built. No roping or fencing is planned in the CP area.

e. Aerial Sweep

Two commercial helicopters for security aerial sweeps and SGZ surveillance during shot time will be obtained. This support will be available at D-3. Mobile radios will be provided for communication in both helicopters.

f. Roadblock

If possible, roadblock communications will be on the Colorado Highway Patrol (CHP) net. If not, communication will be maintained with "Westcol" radio telephones. A CHP advisor will be at the CP on D-Day to assist.

g. Personnel

In addition to the AEC Security Officer, 9 guards will be available. This will allow 24 hour coverage for 7 days a week at SGZ (Security Headquarters). The security effort at the CP will be handled by overtime guards. It is assumed that guard personnel will be AEC subcontracted, and that they will furnish their own support except for vehicles and radios.

F. LASL SUPPORT

Support items for LASL are shown in Figure VI. 14.

In addition, the J-1 and J-6 trailers will be equipped with 2 or more single beds in each, stoves or hot plates, refrigerators, sinks, tables, and chairs.

G. PROGRAM MANAGER SUPPORT

The requirements of the PM are shown in Figure VI. 15. This includes administration, clerks, and a laborer for:

1. Material Functions

Minor items will be purchased as needed. These will primarily be local petty cash items. Shipping and receiving will be available with the necessary packing materials.

2. Subcontract Administration

Subcontracts will be directed towards using local services where practical.

3. Public Information/Observer Support

Transportation from Grand Junction to the observation area on D-1 and D-Day will be made available.

User LASL	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Personnel																															
Tech Occupancy						11	11	11	18	18	14	22	22	11																	
TM Support Rad Safe														2	2						2	2	2	2	2	2	2				
Total Personnel						11	11	11	18	18	14	22	22	13	2						2	2	2	2	2	2	2				
Vehicles - Sedan						7	7	7	11	11	9	13	13	11	2						2	2	2	2	2	2	2				
4 x 4 Pickup											1	1	1																		
Total Vehicles						7	7	7	11	11	10	14	14	11	2						2	2	2	2	2	2	2				
Mobile Radios									2	2	2	2	2																		
Base Station Radios (A&F Trailer)									1	1	1	1	1																		
Telephone - Outside Line						1	1	1	1	1	1	1	1	1	1						1	1	1	1	1	1	1				
LASL Phone Net						1	1	1	1	1	1	1	1	1	1																
A&F to WHS (Hotline)						1	1	1	1	1	1	1	1	1																	
A&F to AEC-OCC						1	1	1	1	1	1	1	1	1	1																
Office Space - On-Site																					4 Trailers,						1, 120 ft			
Office Space - Off-Site							N	O	N	E																					

Figure VI. 14
LASL Support

Program Manager Support	D-Minus Months			D-Minus Weeks									D Day	D-Plus Weeks					Decay	Start Drillback ↓ D-Plus Weeks									D-Plus Mos		
	5	4	3	9	8	7	6	5	4	3	2	1		1	2	3	4	5		26	27	28	29	30	31	32	33	34	10	11	12
Program Manager Personnel		1	2	2	2	6	6	6	8	9	10	11	11	10	6	4	1		1	3	4	3	4	3	3	3	4	1	1	1	1
Vehicles																															
Sedans W/O Radio			1	1	1	1	1	1	1	2	2	3	3	2	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Pickup W/O Radio		1	1	1	2	2	2	2	2	2	2	2	2	2	2	2				1	1	1	1								
Total Vehicles		1	2	2	3	3	3	3	3	4	4	5	5	4	3	3	1		1	2	2	2	2					1	1	1	1
Mobile Radios							2	2	2	2	2	2	2	2																	
Base Radios							2	2	2	2	2	2	2	2																	
Telephone Lines																															
Site to Outside		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Town to Outside		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Office Space																															
Site - 10 x 50 ft		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Town - 2 x 50 ft (In hundreds sq ft)			2	2	2	2	2	4	4	10	10	10	10	10	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1

Figure VI. 15
Program Manager Support

4. Travel Reservations

Travel reservations and motel/hotel reservations for project participants will be handled as necessary from the PM's office.

5. Miscellaneous Functions

Other required activities such as accounting, mail receiving and dispersement, vehicle distribution, communications, and clerical pool administration will be handled by the PM.

VII. ENGINEERING & CONSTRUCTION PLAN

The purpose of the Engineering and Construction (E&C) Plan is to identify major items that will require E&C effort.

The items delineated in this plan include all E&C activities in the 3 phases of Project Rulison.

A. PHASE I

During Phase I, the geologic, hydrologic and topographic conditions in the proposed test area will be determined and evaluated from both the technical and safety viewpoints.

1. Well R-EX

R-EX, the Site Exploratory and Test Well is located 1,695 ft FSL, 2,236 ft FWL, Sec. 25, T7S, R95W, Garfield County, Colorado.

a. Drilling Program

1) TD:

8,516 subsurface, drilled below the anticipated location of WP.

2) Casing:

Surface to 500 ft, 10-3/4 in OD
Surface to 6,365 ft, 7-5/8 in OD
5,860 to 8,514 ft, 5-1/2 in OD

3) Minimum ID:

Surface to 5,860 ft, 6.97 in
5,860 to 8,514 ft, 4.78 in

4) Drilling Media:

Surface to 500 ft, mud
500 ft to 2,010 ft, air
2,010 ft to 4,030 ft, air and foam
4,030 ft to 6,365 ft, mud
6,365 ft to 7,084 ft, air
7,084 ft to 8,516, mud

5) Coring:

3-in diameter and sidewall cores in Wasatch and Ohio Creek Formations, and 2-7/8 in diameter in the Mesaverde Formation. The core was wrapped on-site and shipped to a commercial core laboratory for surface gamma logging, photography, porosity-permeability-water saturation determination, wrapping and temporary storage.

The cored intervals were:

Formation	Footage	Cored Interval
Wasatch	52	4,125 to 4,277 ft
Ohio Creek	53	6,009 to 6,062 ft
Mesaverde	60	7,060 to 7,120 ft
Mesaverde	60	7,260 to 7,320 ft
Mesaverde	60	7,500 to 7,560 ft
Mesaverde	60	7,840 to 7,900 ft
Mesaverde	60	8,060 to 8,120 ft
Mesaverde	60	9,350 to 8,410 ft

6) Logging:

a) Surface to 500 ft, IES, caliper-sonic

b) 500 ft to 6,365 ft

i. IES

ii. Borehole compensated (BHC) sonic-caliper

iii. Variable density sonic log (VDL)

iv. Gamma-epithermal neutron

v. Multishot directional survey

vi. Temperature log

vii. BHC density-caliper

viii. Acoustic cement bond log

ix. 3-D cement bond log

c) 6,365 ft to 8,516 ft

i. BHC sonic-caliper

ii. 3-D sonic, 3,612 ft spacing

iii. VDL sonic

iv. IES

v. Gamma-epithermal neutron

vi. BHC density-caliper

vii. Multishot directional

viii. Temperature log

ix. Cased hole gamma-epithermal neutron

x. Acoustic cement bond log

6) Directional Control:

Multishot directional surveys indicated a maximum hole inclination of 2^{o}. The bottom of the hole was 55.8 ft from the surface location on a bearing of S 29.6^{o}E.

8) Well Completion:

Wellhead completion hardware suitable for production tests will be furnished.

b. Testing Program

1) Hydraulic Testing

a) Wasatch Formation: Wireline formation sample tests were made at the following depths:

2,029 ft

2,053 ft

2,310 ft

3,288 ft

3,920 ft

4,226 ft

All tests were dry.

b) Ohio Creek Formation: DST's of the intervals 6,026 - 6,062 and 6,145 - 6,165 were made and both tests were dry.

c) Mesaverde Additional Hydrologic Testing: The following zones have calculated water saturations of 80-95% and were drill stem tested individually to determine their water flow capacity:

Interval	Neutron Porosity	Water Saturation	Remarks
(1) 8,030-8,034 ft	6%	85%	
(2) 7,614-7,620 ft	8%	95%	
(3) 7,328-7,336 ft	7-10%	85%	
(4) 7,212-7,214 ft	11%	80%	Fractured interval
(5) 7,092-7,096 ft	10-11%	85%	
7,082-7,088 ft	8-10%	85%	Water entry into borehole observed while coring at 7,084 ft with air

All tests were dry.

The following procedure was used:

i. Perforated 2 holes / ft with bullet gun (4 in OD)

ii. Ran RTTS-RVT (with BHP bombs)

iii. Set packer above perforations and opened test tool. Ran swab to determine water influx.

iv. Pulled BHP bomb and observed charts at the conclusion of swab test.

v. Squeeze-cemented open perforations and prepared to test next interval above at the conclusion of each test.

At the conclusion of the testing of these 5 zones, the cement plugs were drilled out and the liner cleaned out to bottom.

d) Additional zones with calculated water saturations of 85-100% are found in the upper part of the hole in the gross interval 6,500-6,830 ft. However, this part of the hole was air-drilled without any water influx and testing of these zones was eliminated as unnecessary with the concurrence of the USGS.

2) Gas Testing:

a) Initial gas testing was in following individual intervals: Interval #1 - 8, 148-8, 464 ft - 316 ft gross, 70 ft of perforations. Interval #2 - 7, 886-8, 072 ft - 186 ft gross, 56 ft of perforations. Interval #3 - 7, 634-7, 844 ft - 210 ft gross, 72 ft of perforations. Interval #4 - 7, 302-7, 576 ft - 274 ft gross, 52 ft of perforations.

Perforations in each interval were as follows:

Interval #1	Interval #2	Interval #3	Interval #4
8, 148-8, 154 ft	7, 886-7, 890 ft	7, 634-7, 642 ft	7, 302-7, 308 ft
8, 156-8, 172 ft	7, 892-7, 914 ft	7, 648-7, 654 ft	7, 402-7, 404 ft
8, 200-8, 208 ft	7, 952-7, 966 ft	7, 668-7, 678 ft	7, 410-7, 416 ft
8, 280-8, 288 ft	8, 050-8, 060 ft	7, 680-7, 686 ft	7, 480-7, 484 ft
8, 318-8, 326 ft	8, 066-8, 072 ft	7, 720-7, 734 ft	7, 526-7, 530 ft
8, 430-8, 434 ft		7, 776-7, 782 ft	7, 534-7, 538 ft
8, 440-8, 444 ft		7, 812-7, 824 ft	7, 540-7, 544 ft
8, 448-8, 464 ft		7, 834-7, 844 ft	7, 550-7, 554 ft
			7, 556-7, 568 ft
			7, 570-7, 576 ft

The testing procedure follows:

i. Connected air compressors and removed water from inside casing.

ii. Perforated interval with 2 holes / ft (Bullet gun) in dry casing.

iii. Ran RTTS-RVT tools (with BHP bombs). Set packer above interval to be tested.

iv. Opened tool and measured flow rate with critical flow prover.

v. Pulled RTTS-RVT tools and observed charts.

vi. Set bridge plug 20-30 ft above open perforations, and tested next zone.

b) After the individual interval tests were completed, the well was shut-in and the buildup pressure monitored. A pressure survey was made at the end of the shut-in period. When the approximate static pressure was reached, the well was placed on production at near capacity. After approximately 72 hours, a flowing temperature survey was made. Two complete runs were made to verify the gas entry points. Each run spanned the entire Mesaverde section. A spinner survey was also made. After completing the survey, flow testing was continued for 3 weeks. The well was then shut and a subsurface pressure probe was run in the well, and the buildup monitored and recorded.

c) One additional long-term production test is planned. The procedure for this test will be obtained from the short-term test. The long-term flow test will be run to sample the formation away from the well bore. A surface recording bottom hole pressure bomb will be run, and the subsurface pressure will be continuously recorded during the test. A flow rate should be selected that can be sustained for an adequate flow period, and this rate held constant within acceptable limits. The conduct of the test can be accomplished with the equipment diagrammed in Figure VII. 1. At the conclusion of the long-term flow test, the well will be shut in for pressure buildup.

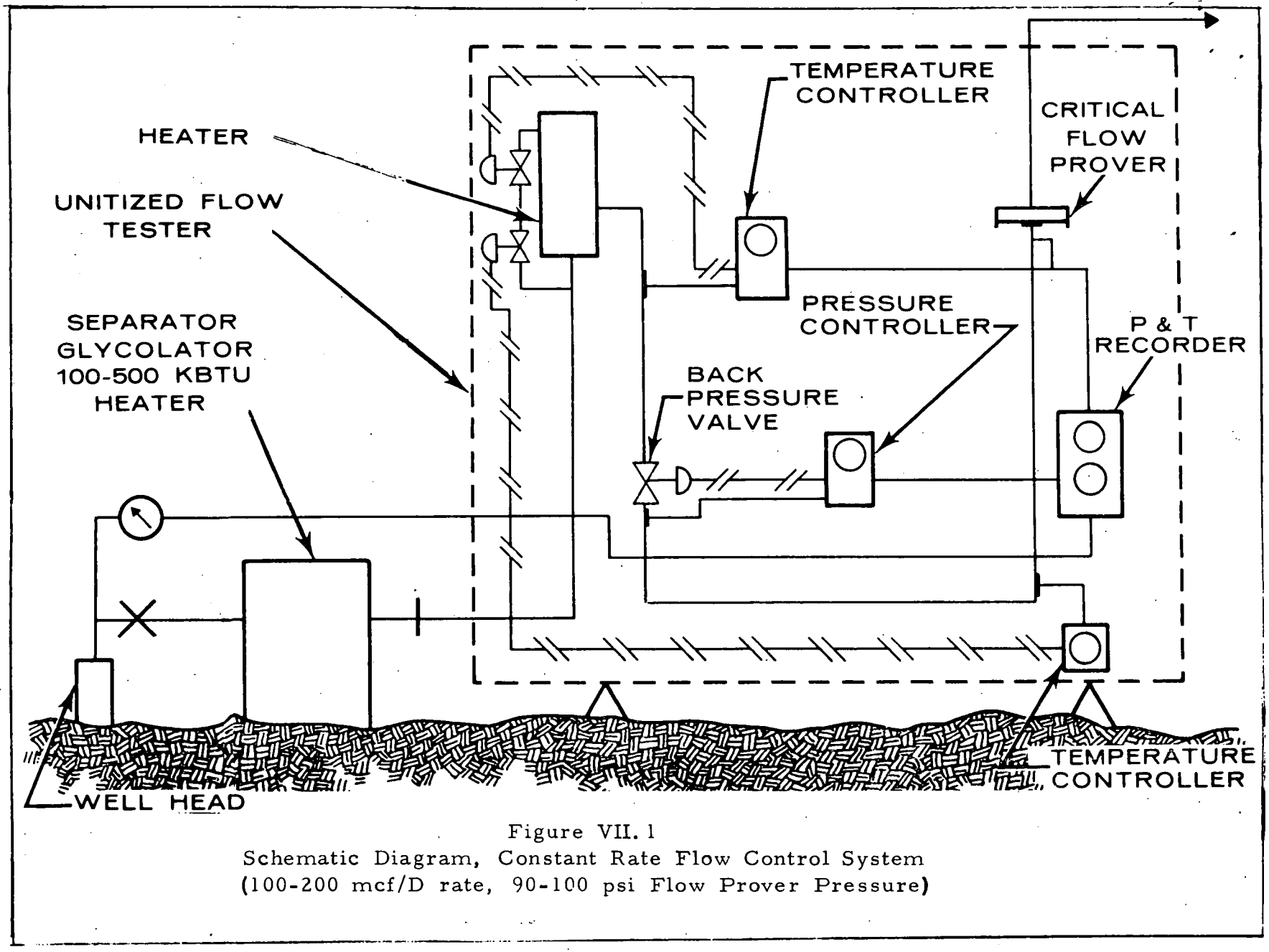


Figure VII. 1
Schematic Diagram, Constant Rate Flow Control System
(100-200 mcf/D rate, 90-100 psi Flow Prover Pressure)

2. General Effort

In addition to clearing the work area around R-EX, a road was graded from Morrisania Mesa to the location of R-EX. This road will serve the proposed CP and the proposed SGZ. The road and site area will continue to be maintained.

B. PHASE II

Phase II is the nuclear operation phase from acceptance of the site until the site is secured after detonation and before drillback.

1. Well R-E

R-E emplacement hole is located 1,813 ft FSL, 1,976 ft FWL, Sec. 25, T7S, R95W, Garfield County, Colorado, or approximately 300 ft northwest of R-EX.

a. Drilling Program

1) TD:

8,700 ft, i.e., WP + 270 ft. Exact WP will be determined on basis of core and logs.

2) Drilling Medium:

Surface to TD, mud.

3) Coring:

Coring will be done in the interval between 8,400 ft and 8,460 ft. Cores to be described; each foot divided into 6-in pieces and wrapped; and one piece sent to LASL, the other piece retained for reservoir property analysis. Cores sent to LASL will include those taken within ± 10 ft from the determined WP.

4) Casing:

a) Surface casing of 16 in will be run to approximately 800 ft and 10-3/4 in casing from surface to TD.

Section	Length	Interval	Weight*	Grade*	Thds.
1	2,500 ft	0-2,500 ft	51#	N-80	ST&C
2	1,000 ft	2,500-3,500 ft	51#	J-55	ST&C
3	1,200 ft	3,500-4,700 ft	51#	N-80	ST&C
4	1,000 ft	4,700-5,700 ft	51#	P-110	ST&C
5	800 ft	5,700-6,500 ft	51#	S-95	ST&C
6	2,200 ft	6,500-8,700 ft	55.5#	S-95	ST&C

No intermediate casing string is anticipated.

*If particular grades of casings are not available, a grade equal to or better will be used.

b) Float Shoe: One regular type required, on bottom of string.

c) Float Collar: One regular type required, place 2 joints (60ft-80ft) above guide shoe.

d) Stage Collars: Two required, placed at depths of approximately 7,350 ft and 1,000 ft below the surface. The lower stage collar will allow a second attempt to be made to complete Stage 1 in the event circulation is lost while cementing.

e) Centralizers: Approximately 37 required and placed about 100 ft apart through cemented intervals. Vane-deflector type centralizer will be employed.

f) Casing Surface: Sand blast exterior of joints which are to be cemented (lower 2,700 ft and upper 1,000 ft) to assist cement bonding to pipe. In addition, sand-epoxy coating to be placed on 400 ft of casing which, when installed, will be positioned in the interval, 7,500-8,060 ft, which is estimated to be immediately above the top of the nuclear fractured zone.

g) Thread Make-up: Pipe make-up will be done with hydraulic casing tongs using 5,100* ft-lbs of torque. A thread-lock compound will be applied to the bottom 3 joints and a high quality thread lubricant applied to all other connections.

5) Dimensions:

Section	ID	Drift	Coupling OD
1-5	9.850 in	9.694 in	11.750 in
6	9.760 in	9.604 in	11.750 in

6) B_4C Container:

An annular container and appropriate transition pieces will be fabricated, welded to the casing, and filled with B_4C as per LASL J6 Sketch J6-SK-PS-5. A portion of that sketch showing the installation detail is reproduced as Figure VII.2.

7) Cementing:

The volumes of cement slurry required for this operation will be determined by calculations based on a 3-arm caliper survey of the bore hole, with an additional 15% added to the caliper volume.

a) Stage 1: 6,000-8,600 ft through casing shoe at a depth of approximately 8,600 ft.

Chem-Comp
Slurry Weight - 14.8 lb/gal
Slurry Yield - 1.32 cu ft/sack
Water Ratio - 6.32 gals/sack
Compressive Strengths - 24 hrs, 3,000 psi @ 225°F

Alternate --

Sloflo RFC (Regulated Flow Cement)
Slurry Weight - 14.2 lb/gal
Slurry Yield - 1.6 cu ft/sack
Water Ratio - 7.9 gals/sack
Compressive Strengths - 24 hrs, 1,800 psi @ 225°F

*Optimum value range, 3,900-7,600 ft-lbs.

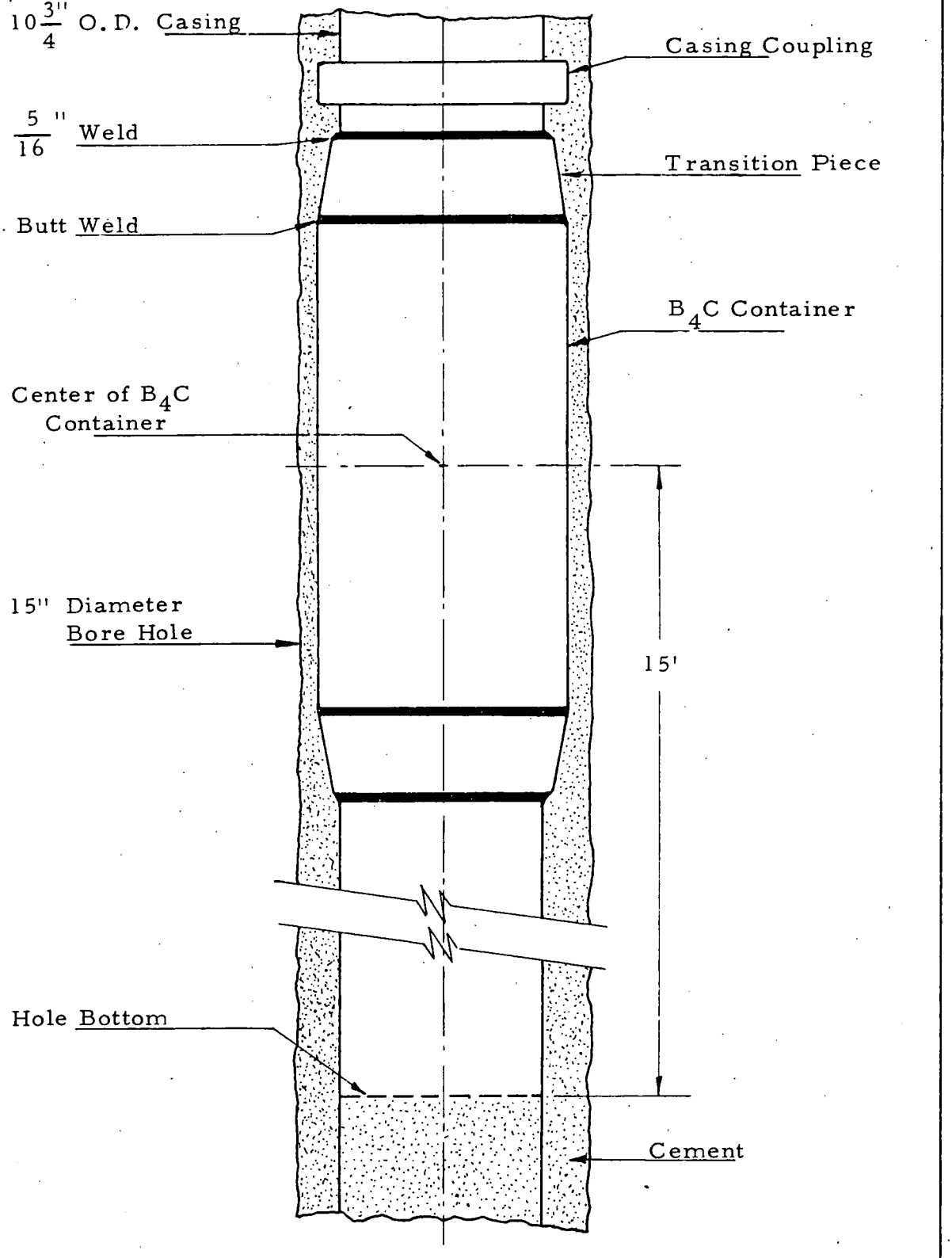


Figure VII. 2
B_4C Container

b) Stage 2: Surface - 1,000 ft, through stage collar placed at a depth of approximately 1,000 ft, Class "G" cement with 3% calcium chloride.

Slurry Weight - 15.8 lbs/gal
Slurry Yield - 1.15 cu ft/sack
Water Radio - 4.97 gals/sack
Compressive Strengths - 24 hrs, 3,600 psi @ 80°F

Note: This slurry design will also be used for the surface casing.

If mud cake removal is a problem, consideration will be given to the use of a chemical wash or scavenger slurry ahead of the cement. The plug displacement cementing method will be used. Verification of the cementing will be made through the use of temperature surveys and the acoustic cement bond log at approximately 72 hrs after completion of the cement displacement.

Additional cementing will be performed, if necessary, by conventional squeeze methods using a slurry which will be compatible with the primary cementing design.

The bottom of R-E will be as shown in Figure VII. 3. The top wiper plug will be released and then followed with enough cement to raise the top approximately 50 ft above the WP. The cement will then be dressed off with a bit to the WP.

8) Logging:

a) The following wet hole logs are required from surface to surface casing point (800 ft):

i. Gamma-neutron (Sidewall)

ii. 3-arm caliper

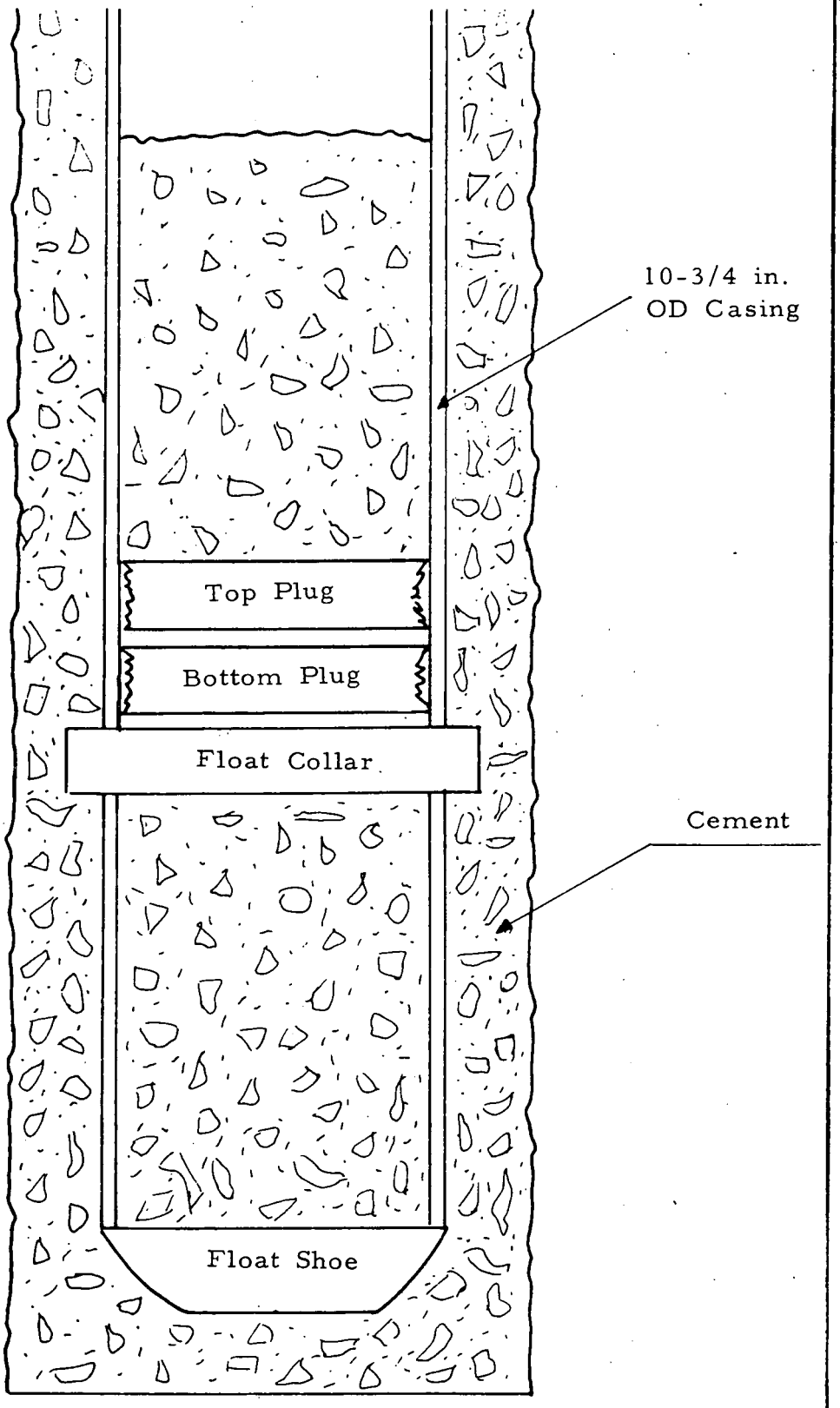


Figure VII.3
Bottom Hole Configuration

b) Surface Casing point to TD:

i. Gamma-epithermal neutron

ii. Multi-shot directional survey

iii. BHC density

iv. 3-arm caliper

9) Directional Control:

Deviation shall not be greater than 5 degrees at TD with maximum angular build-up less than 1 degree/100 ft.

10) Hole Check:

The emplacement hole will be checked by running a 9 in diameter by 15 ft minimum length mandrel from surface to TD. This will be done after cementing and bailing operations are complete. The 80,000 pound static test will be performed in a dry hole. This check will be witnessed by both LASL and NVOO representatives. In addition, an impression block will be run to determine some of the bottom of the hole characteristics.

After 30 days, a dryness test will be run and leaks, if any, will be repaired and just prior to "Downhole" operations, an additional dryness test will be performed.

b. Testing Program

1) Hydrologic Testing:

None

2) Gas Testing:

None

c. Wellhead

The wellhead will be in a concrete pad 10 ft x 10 ft x 1 ft.

2. SGZ

a. General Layout

1) The layout of SGZ is shown in Figure VII. 4.

At SGZ there will be:

a) LASL - J-1 Trailer: See support for specifications

b) LASL - J-6 Trailer: See support for specifications

c) Wellhead Shack: The specifications for the wellhead shack are shown in Figure VII. 5.

For security reasons a 6 ft hogwire fence, topped with 3 strands of barbed wire, will enclose the shack. Clearance on the inside will be 10 ft and the maximum outside clearance, permitted by the limited real estate, will be used, not to exceed 25 ft.

d) Security Van: The van used by security will be situated outside the wellhead shack so that the shack and fence will be under observation. Emergency lighting will be furnished by a separate illumination system powered by an emergency generator, located beside the van.

e) Winch:

i. Capacity: 10, 500 ft of 3/4 in cable and 36, 000 pounds cable tension.

ii. Minimum drum diameter is 28 in.

iii. Cable speed is to be smoothly variable from 0 to 1, 000 ft per hr in both directions.

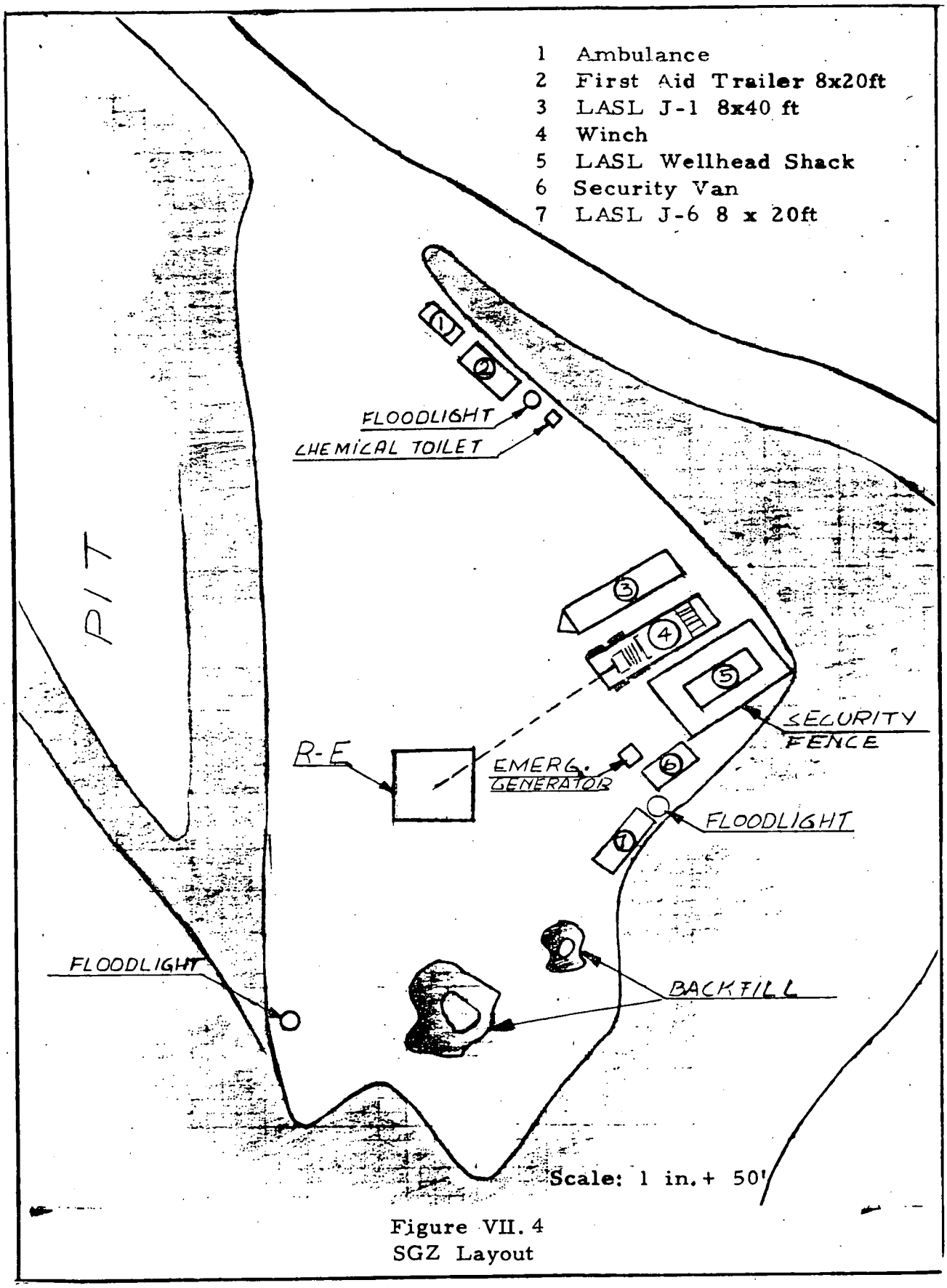
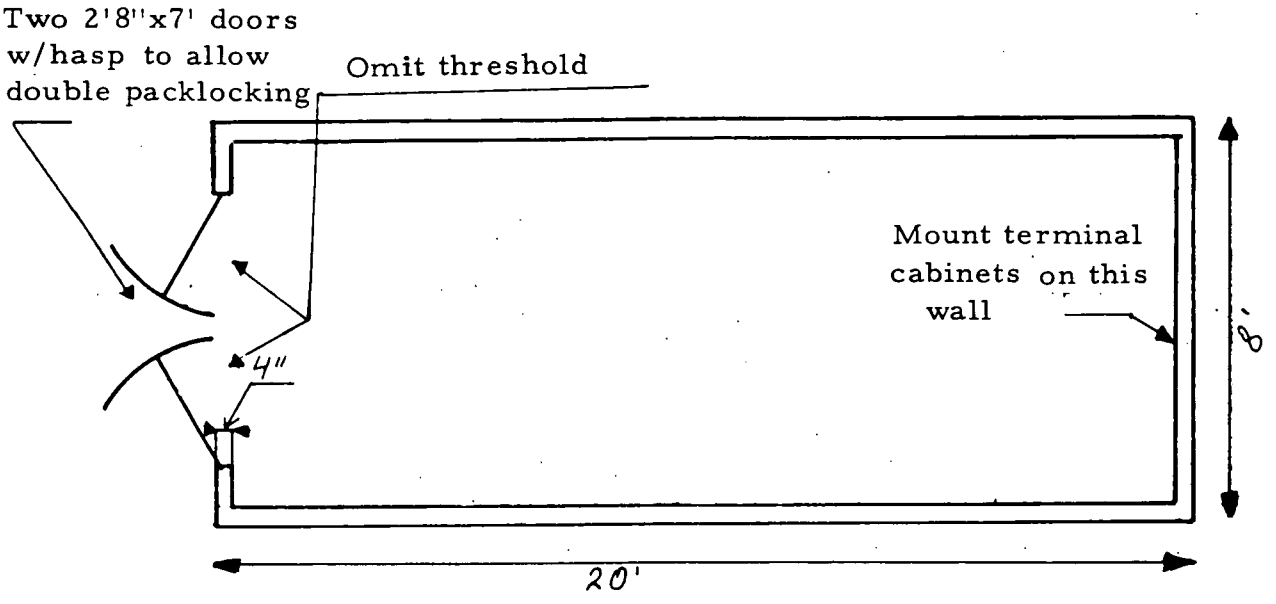


Figure VII. 4
SGZ Layout



1. Ceiling height to be 8 ft minimum.

2. Floor to be built to allow moving a 2,000 lb load any place on the floor on a frame with 4 casters 2 in wide with 6 in diameter.

3. Building will be painted with fire retardant paint.

4. Provide forced ventilation of 20 air changes per hour. Filter incoming air with 1 in fiber glass filters and maintain temperature at 72°F.

5. Build 3 pallets 4 x 8 ft to same specifications as floor. Pallets to be placed in front of Wellhead Shack doors at same elevation as floor so carts may be rolled in and out.

6. Wellhead Shack to be tied down as follows:

   a. Install anchors in concrete 8 ft below grade near each corner with a 1 in anchor rod extending above ground.

   b. Attach 1 in wire rope to anchor rod and loop over the roof. Place a 4 in x 12 in timber between the wire rope and the roof.

Figure VII. 5
Wellhead Shack

iv. To have power down capability

v. May be either skid or truck-mounted

vi. It shall have deadman type controls

vii. It shall have a cable tension indicator

viii. It shall have been tested to the 36, 000 lb capacity prior to installing the downhole cable on the drum. This test is to be witnessed by a LASL representative.

f) Headframe:

i. The minimum working height is 20 ft

ii. The minimum sheave diameter is 36 in

iii. The sheave to be grooved to fit the downhole cable (approximately 0. 72 in diameter)

iv. To withstand a cable tension of 36, 000 lbs

v. The headframe and winch may be combined in one package, if feasible.

vi. It shall be tested to the 36, 000 lb capacity prior to any downhole operations. This test is to be witnessed by a LASL representative.

g) Crane:

i. The minimum working height is 40 ft

ii. The load rating at 15 ft radius is a minimum of 15, 000 lbs

iii. It should be truck-mounted for mobility

h) Reel Jacks: Reel jacks to handle the downhole cable reel to allow installation of the cable on the winch drum.

i) Terminal Cabinets: Specifications are shown in Figure VII. 6.

b. Emplacement

1) Mandrel Run:

The emplacement system will be checked by running a 12, 000 lb mandrel from surface to TD using the emplacement winch and downhole cable.

2) SGZ Preparation:

a) The site will be graded after removal of drill rig to accommodate the above equipment plus stemming material and parking spaces for 12 vehicles.

b) The trailers will be blocked up, cribbing and walkways constructed as required.

3) Explosive Assembly:

The explosive will be assembled and checked by LASL.

4) Downhole Cabling:

The explosive will be emplaced using Amerigraph cable type 34J71B or equivalent containing 1 RG-58/U coax and 32-No. 22 conductor wire. This cable will be terminated in the Wellhead Shack Terminal Cabinet. This cable must be sent to LASL for check-out and installation of seals and connectors before going to site.

c. Stemming R-E

1) Material:

Stemming material will be as specified in Figure VII. 7. During storage, waterproof membranes will be placed over and under the stemming material to prevent moisture migrating up or falling onto the stemming material.

NEMA type 12 terminal cabinet, 30 in. x 6 in. with: 1 in. plywood sheet covering the interior back of the cabinet. Four-inch double-hinged hasp for padlocking door. Two 50-point terminal blocks equal to "Buchanan" No. 06650 spaced 6 in. apart. Three 2-in. and 3 1-in. Meyer's hubs installed in the bottom of the cabinet, complete with pipe plugs.

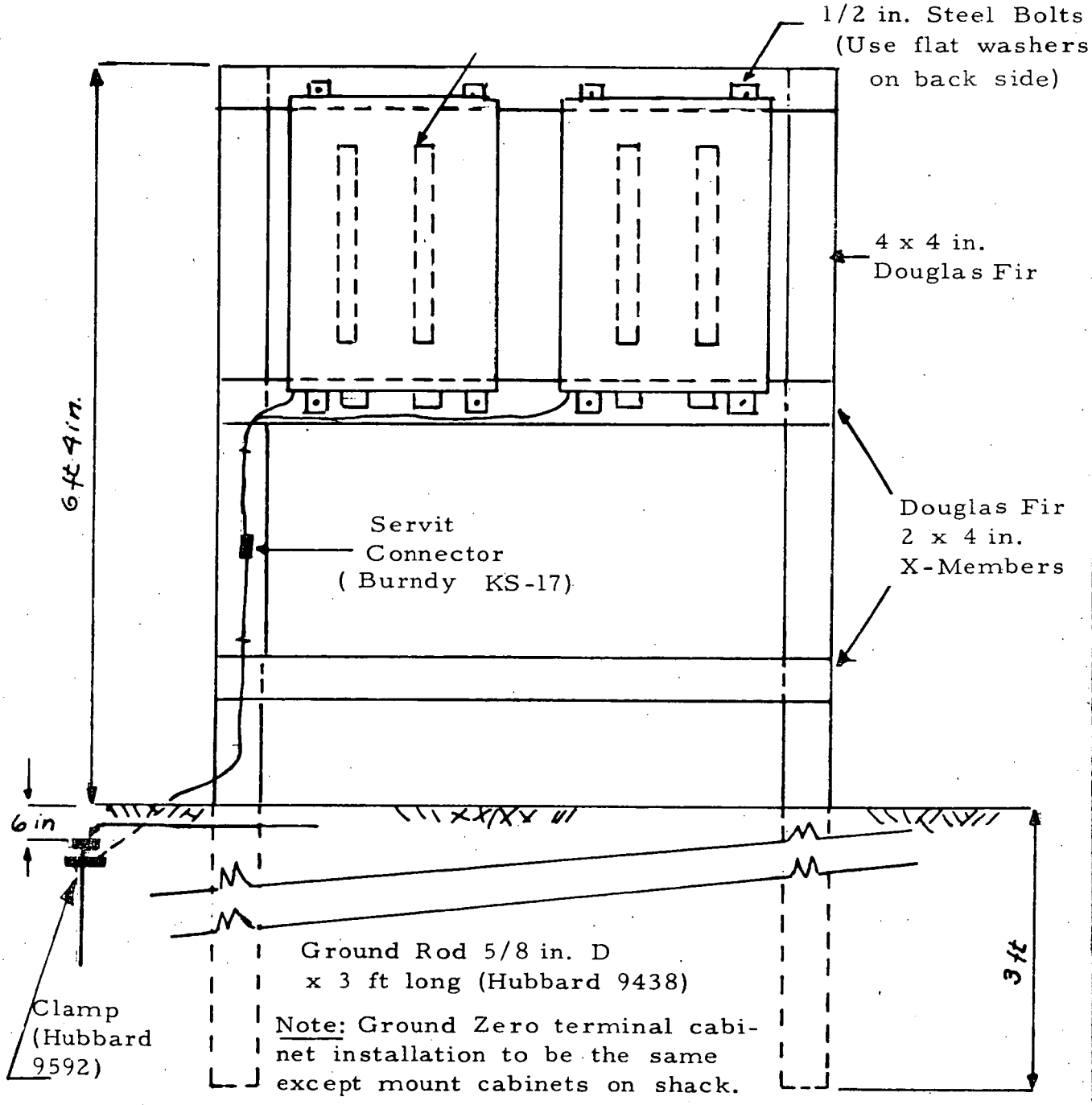


Figure VII.6
Terminal and Splice Cabinet Detail

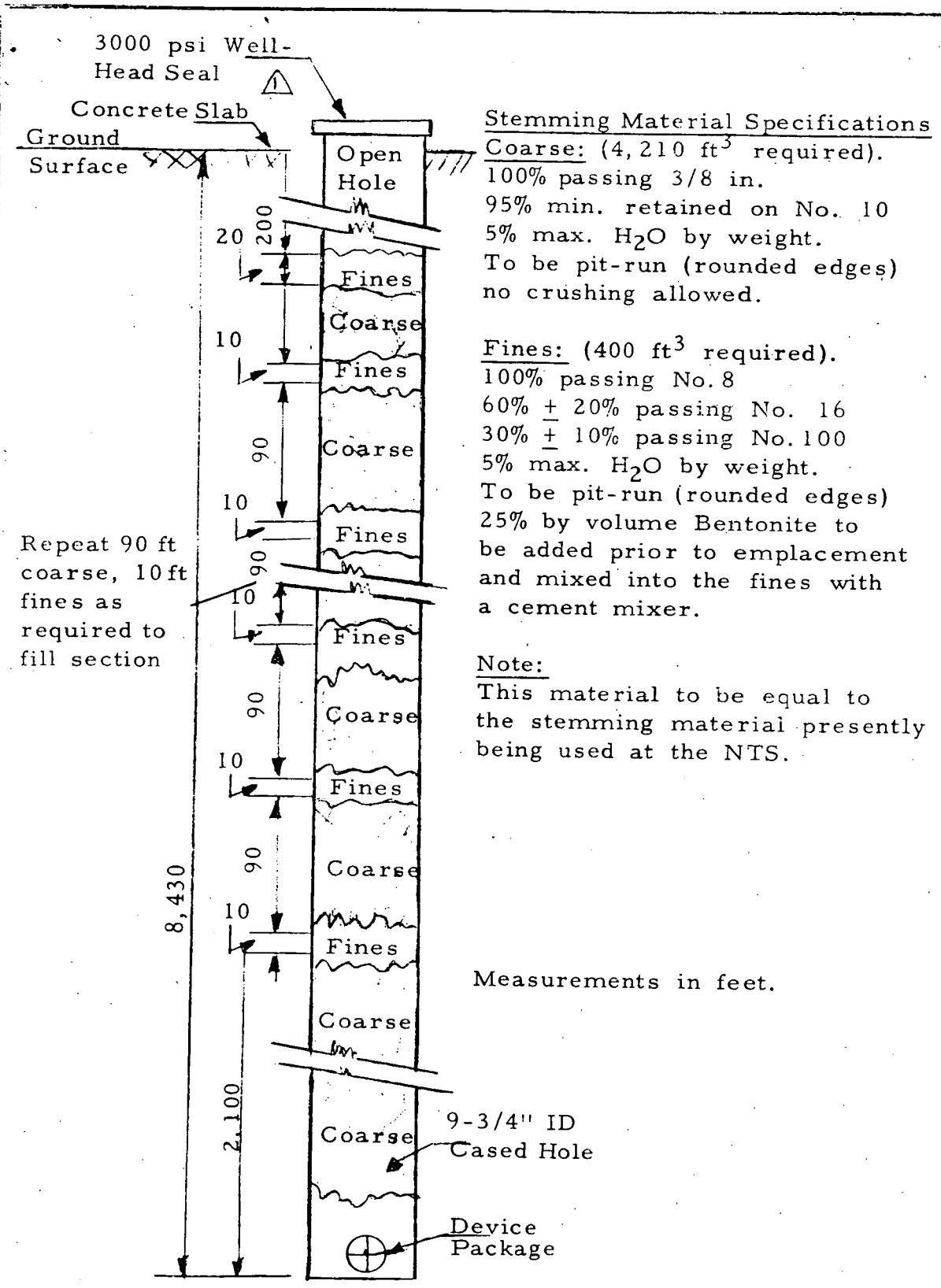


Figure VII. 7
Stemming Plan, Well R-E

2) Equipment:

a) Front-end loader, rubber-tired, 1/2 cubic yard capacity to feed the hopper.

b) Hopper, 1 cubic yard capacity, capable of controlling the flow into the hole from 0 to 6 cubic yards per hour.

c) A "Halliburton" line for periodically sounding the hole to determine the actual stemming rate. This line should be power driven.

d) Cement mixer for mixing bentonite with "fines."

3) Operations:

The hole will be stemmed per LASL directions. The stemming operation will be witnessed by LASL representatives.

4) Wellhead:

After stemming the wellhead will be sealed to withstand 3,000 psi internal pressure.

d. Stemming R-EX

1) Material:

R-EX will be stemmed with sand and water, applied simultaneously.

2) Equipment:

a) Front-end loader, rubber-tired, 1/2 cubic yard capacity to feed the hopper.

b) Hopper, 1 cubic yard capacity, capable of controlling the flow into the hole from 0 to 6 cubic yards per hr.

c) A "Halliburton" line for periodically sounding the hole to determine the actual stemming rate. This line should be power driven.

d) 200 gal storage tank and gasoline driven water pump.

3) Operation:

The hole will be stemmed per LASL directions. The stemming operation will be witnessed by LASL representatives.

4) Wellhead:

After stemming the wellhead will be sealed to withstand 3,000 psi internal pressure.

e. RAMS Units Installation

Eight RAMS units will be installed on fence posts spaced approximately 45^{o} intervals around SGZ on a 200 to 300 ft radius. An additional RAMS unit will be mounted at the wellhead. One pair of WD-7 field wire will be run from each of the 9 RAMS units to the Terminal Cabinet on the Wellhead Shack. Twenty-five ft of slack will be left at each end of these wires. Wire will be installed in or covered with steel culvert where required to protect it from mechanical damage, e.g., under roadways. Cabling is shown in Figure VII.8.

3. CP Area

The CP is located about 2.6 miles from SGZ and is in the SE 1/4 of the SW 1/4 of the SW 1/4 of Section 14, T7S, R95W.

a. Grading

The area of the CP will be graded to accommodate 14 trailers, 3 of which will be moved from SGZ prior to shot time, as indicated in Figure VII.9. Parking for 40 vehicles will be provided. The area will be approximately 25,000 sq ft.

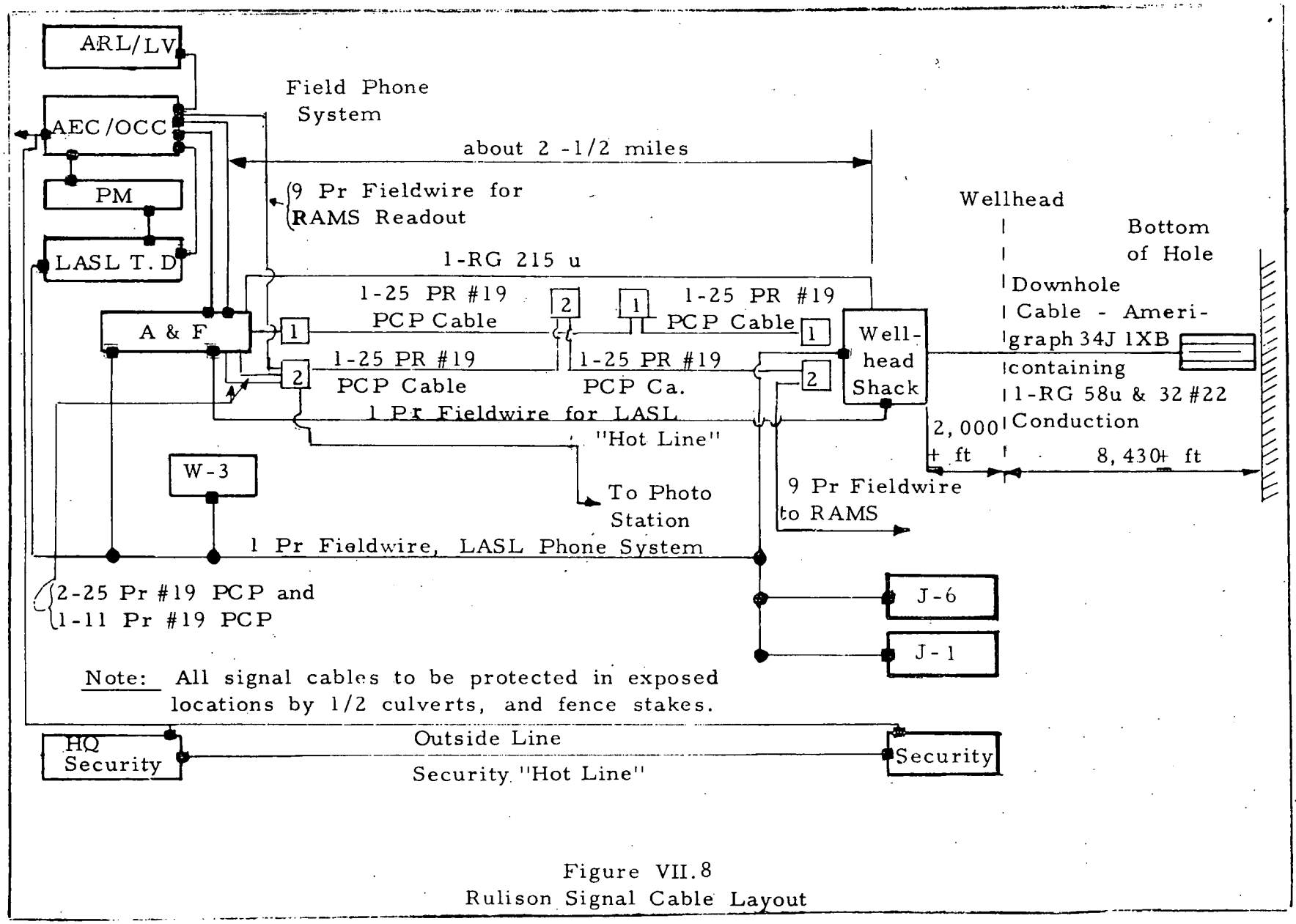


Figure VII.8
Rulison Signal Cable Layout

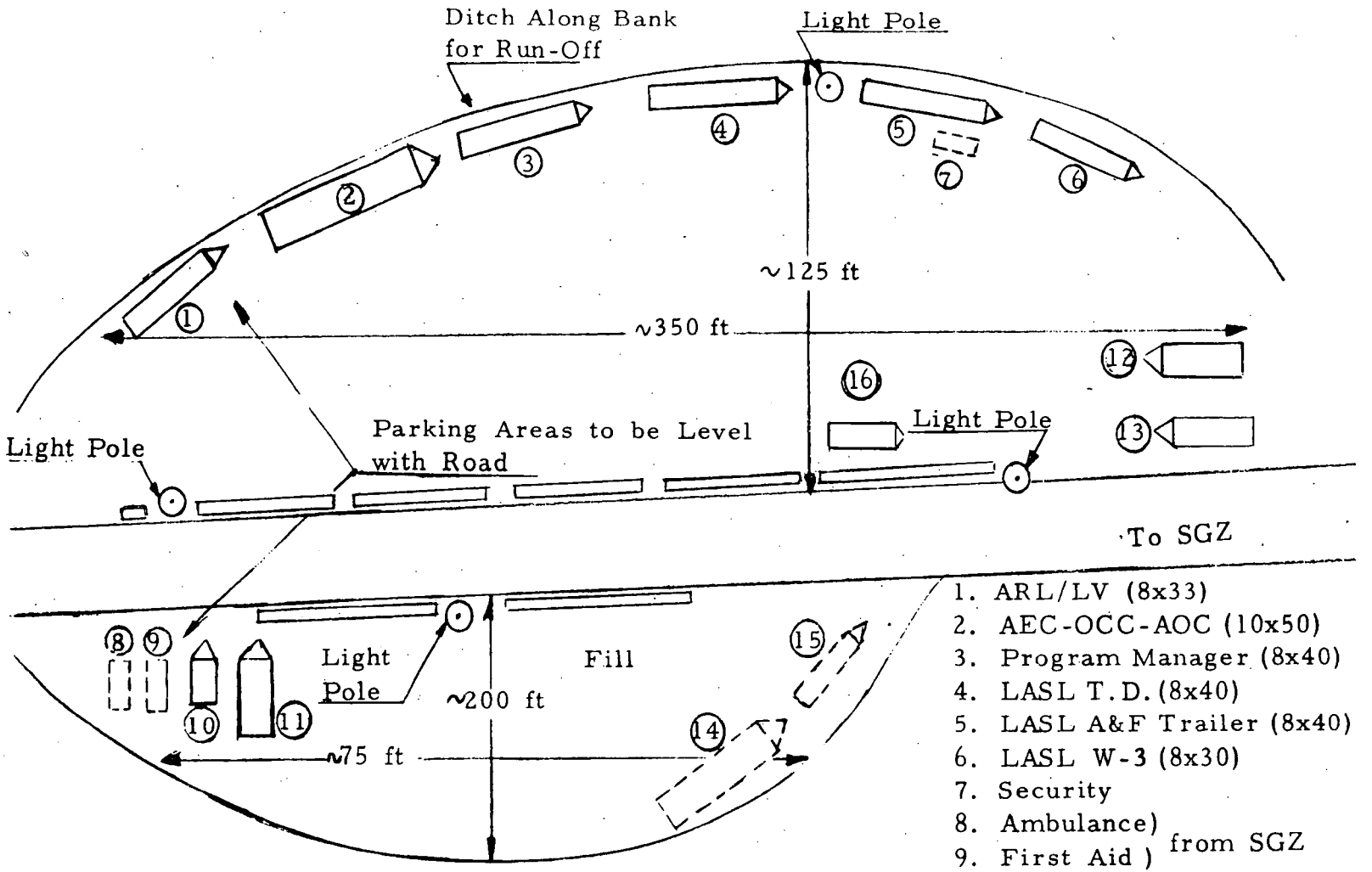


Figure VII. 9
Control Point Layout

b. Power Distribution CP

Single phase power from a commercial source will be distributed.

c. Radio Antenna Tower

A radio antenna tower will be constructed near the CP for low band communications to a repeater.

d. Terminal Cabinet

Cable terminal cabinets will be built to specifications of Figure VII. 6.

4. Cabling From SGZ to CP

These cables will be protected where necessary, e. g., road crossings, from damage, by installation in steel culverts. 25 ft of slack will be left at each end. Cabling is shown in Figure VII. 8.

5. Off-Site Safety

a. A water well will be drilled near the Gaging Station on Battlement Creek.

b. Surveys will be made of seismic station locations as required.

6. Post-Shot

a. SGZ

After the area is cleared and technical considerations satisfied, a fence will be constructed around SGZ. Within the fenced area will be 4 trailers:

2 - Radiological Safety Trailers
1 - LASL J-6 Trailer
1 - Program Manager's Trailer

b. Power Distribution

Adequate power will be distributed to the 4 trailers.

7. Observer Area

An area of approximately 2,000 sq ft will be cleared north of the Colorado River. The access road will allow bus-type vehicles to bring in official observers. In the same vicinity, 2 areas will be cleared for the helicopter pads with a 75 ft radius clearance.

C. PHASE III

1. R-PS-1 Well

a. Drilling Program

1) TD:

Top of chimney (approximately 8,030 ft)

2) Minimum ID:

6-1/8 in (4-1/2 in in Alt. A)

3) Coring:

None

4) Casing:

a) Preferred Plan: Re-entry of R-E to top of chimney through 10-3/4 in casing.

b) Alternate A: R-E site spalled; therefore, re-enter R-EX. 7-5/8 in casing to 6,000 ft, 5-1/2 in casing 6,000 ft to 7,500 ft (4-1/2 in open hole 7,500 ft to top of chimney).

c) Alternate B: Shallow casing or cable problem in R-E and a re-entry problem in R-EX; therefore, move rig and start new hole: 10-3/4 in @ 800 ft, 7-5/8 in to 7,500 ft (6-1/8 in open hole 7,500 ft to top of chimney).

d) Alternate C: Deep casing or cable problem R-E: therefore; mill window in 10-3/4 in and drill new hole segment: 10-3/4 in to problem depth, 7-5/8 to 7,500 ft (6-1/8 in open hole to top of chimney).

5) Drilling Medium:

Surface to 7,500 ft - no requirements. 7,500 ft to top of chimney - air or gas.

6) Direction Control:

If sidetracked hole is required, sufficient directional control will be maintained to hit the top of the chimney within 50 ft of R-E.

7) Logging:

The following dry hole logs will be required:

a) Original Hole:

i. Gamma-neutron

ii. Temperature

b) Alternates:

i. Packer-spinner, if feasible

ii. Casing caliper

iii. Bore-hole photography, if feasible

iv. Temperature, if feasible

v. Cement bond, if feasible

c) Sidetracked Hole:

i. To casing point:

Gamma-neutron
Caliper
Cement bond

ii. Below casing point:

Gamma-neutron
Temperature

8) Well Completion:

a) Wellhead completion hardware suitable for production tests will be furnished.

b) 2-3/8 in tubing to be set to approximately 7,500 ft.

9) Install Gas Monitor Equipment:

This will be used to monitor the blooie lines for radioactivity.

b. Testing Program

For the gas quality and radiation testing program, see the Technical Plan.

2. R-PS-2 Well

If R-PS-2 is to be done the following program is recommended.

a. Alternate A*

Shallow casing or cable problem in R-E; therefore, re-enter R-EX, test perforated zone, reperforating if necessary. If casing is collapsed mill window in 7-5/8 in casing and drill new hole along side original hole to a depth of 9,000 ft. After logging and testing, set another whipstock and drill into chimney.

*Expanded version of Alternate A for R-PS-1

b. Alternate B

If the perferred plan or Alternate C issued for R-PS-1, then re-enter R-EX, test perforated zone, reperforating if necessary and test. If casing is collapsed mill window and drill sidetracked hole to 9,000 ft.

3. Decontamination Pad and Evaporation Pit

A decontamination pad of 25 ft by 25 ft will be constructed next to an evaporation pit of about 30 ft by 30 ft. Both the pad and pit will be sealed with sheets of plastic to prevent percolation of contaminants into the ground water supply. The pad will be constructed so that the runoff will be into the evaporation pit, which will be banked so that normal runoff will be prevented from entering and causing an overflow. The SGZ layout is shown in Figure VII. 10.

4. Fencing

The SGZ area will be enclosed with a "hog wire" fence, topped with 3 strands of barbed wire. There will be a double drive gate at the entrance. Figure VII. 10 shows the fence layout.

5. Flare Stack

The flare stack will be located near R-EX with the water filter tank located on the R-E Pad for ease of drainage into the evaporation pit. If necessary, the flared gas will be ignited. Figure VII. 11 is a diagramatic layout of the gas flaring system.

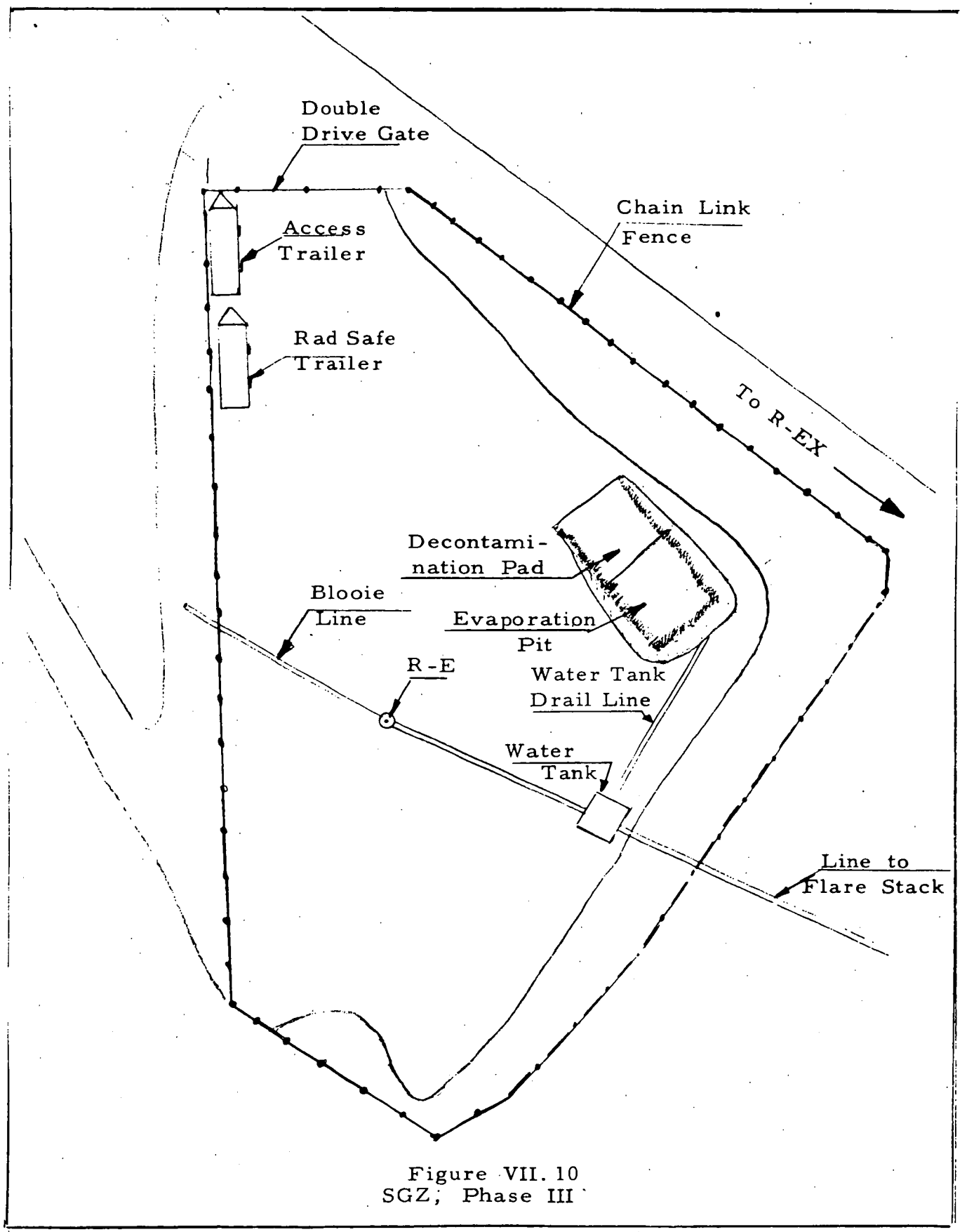


Figure VII. 10
SGZ, Phase III

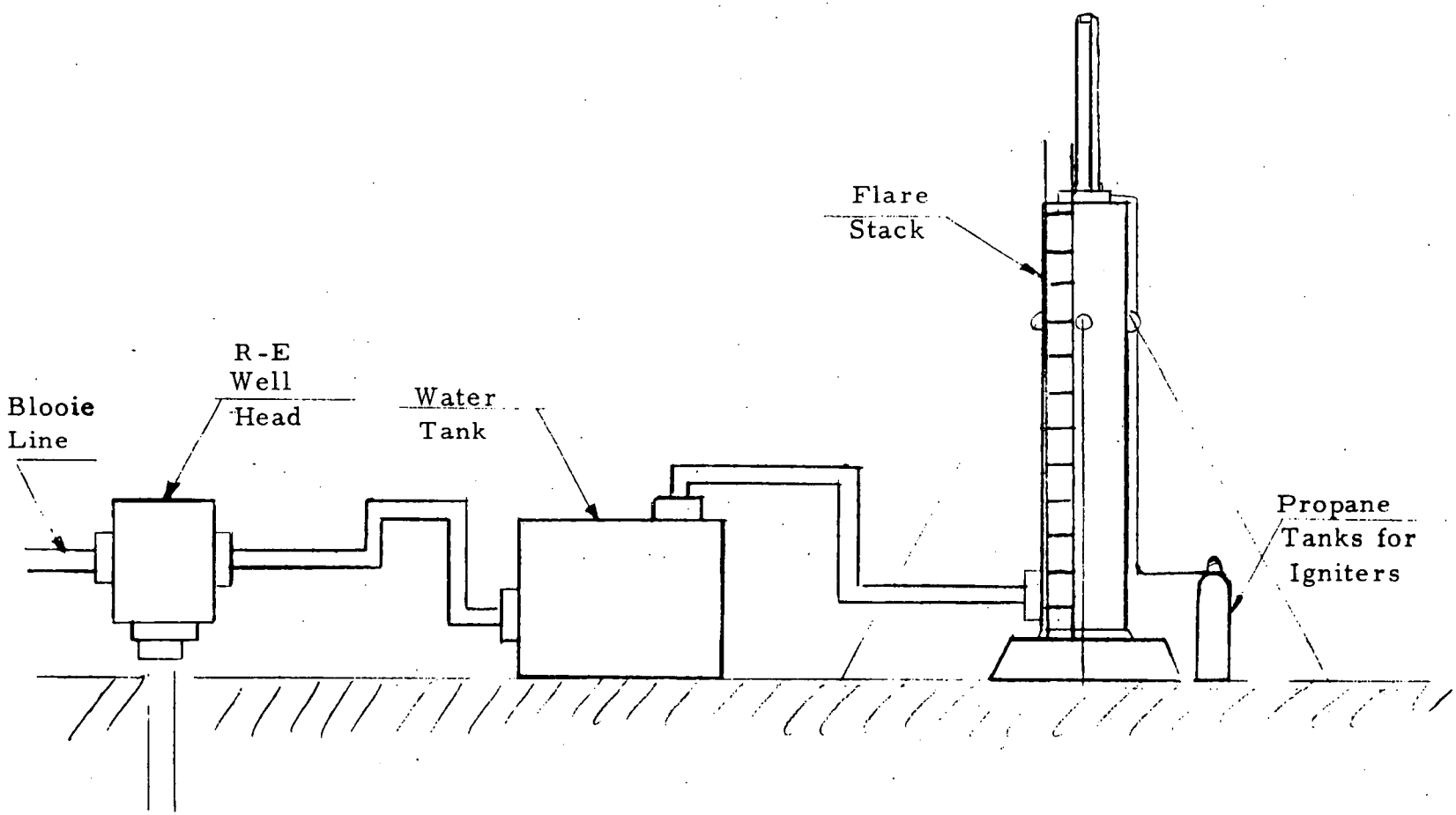


Figure VII. 11
Diagram of Gas Flaring System

VIII. TASK DESCRIPTIONS AND BUDGET ESTIMATES

The task sheets which have been developed include a summary description of the task to be performed and a budget estimate. Some tasks have been defined and estimated in greater detail than others. Significant detail on some Phase III tasks can only be determined after Phase II and the assembly of data not yet available.

A summary of the budget estimates plus contingencies is also included. The contingencies consist of a normal 10% uncertainty in estimating tasks except for those already completed, plus an additional amount for unexpected but reasonably possible conditions such as shot delays, re-entry drilling and radiation problems.

It should be noted that the following budget estimates do not include budgets which the government funds and is responsible for.

PROJECT RULISON

BUDGET ESTIMATE SUMMARY

Accounting No.	Task Description	Budget Estimate (in $K)
4-1-01	Road Const. & Maint.	$ 125
4-1-02	Drill & Complete R-EX	797
4-1-03	Test & Evaluate R-EX	81
4-1-04	Weather Data Acquisition	13
4-1-05	Initial Safety Studies	38
4-1-06	Site Acceptability Report	15
4-2-01	Drill & Check R-E	644
4-2-02	Electric Power	40
4-2-03	Electric Power Distribution	6
4-2-04	Site Illumination	8
4-2-05	ExplosiveEmplacement & Stem.	116
4-2-06	On-Site Telephone Comm.	3
4-2-07	Off-Site Telephone Comm.	15
4-2-08	Low Band Radio Net	23
4-2-09	Public Health & Safety	61
4-2-10	Industrial Safety	12
4-2-11	Aircraft Support	6
4-2-12	Ground Motion & Struct. Resp.	182
4-2-13	Geologic & Hydrologic Studies	10
4-2-14	Meteor. Support for Rad-Safe	60
4-2-15	Security	32
4-2-16	JOI & Observer Effort	23
4-3-01	Drill R-PS-1	175
4-3-02	Test R-PS-1	100
4-3-03	Gas Flaring System	15
4-4-01	Project Management	186
4-4-02	General Construction	76
4-4-03	General Support	220
4-4-04	Surface Transportation	31
4-4-05	On-Site Rad-Safe	80
	Total	$3,193
	Contingency 10%	218
	Contingency Add-On	429
	Grand Total	$3,840

PROJECT Rulison

TASK Phase I-Road and Mat Construction & Maintenance SCHEDULE Completed

TASK NUMBER 4-1-01 DATE 11/15/68 BUDGET $125,000

- TASK DESCRIPTION -

1. Drill sites for R-EX and R-E staked, road and site locations surveyed.

2. Access road constructed from point near center SE/4, Sec. 10, T-7S, R-95W on Morrisania Mesa to R-EX site, a distance of approximately 4 miles.

3. R-EX drill site constructed.

4. Maintain road and drill site.

PROJECT Rulison

TASK Drilling & Completion - R-EX SCHEDULE Completed

TASK NUMBER 4-1-02 DATE 11/18/68 BUDGET $797,000

- TASK DESCRIPTION -

1. Move in rig and drill R-EX in 3 phases:

   a. Drill surface hole segment, run and cement surface pipe (surface to 518 feet).

   b. Drill intermediate hole segment, run pipe and cement (518 feet to 6,367 feet).

   c. Drill producing section, run and cement 5 1/2 liner (6,367 feet to 8,516 feet).

2. Core representative sections of Wasatch, Ohio Creek and Mesaverde Formations.

3. Log 3 hole segments plus an in-pipe logging program.

4. Perform series of hydrologic tests on selected intervals in Wasatch, Ohio Creek, and Mesaverde.

5. Perform series of gas rate tests in the Mesaverde.

6. Install wellhead and surface equipment and move out rig the details of drilling and completion R-EX are presented in the well history, completion summary and test summary.

PROJECT Rulison

TASK R-EX Testing and Evaluation of Test Results SCHEDULE Complete January 15, 1969

TASK NUMBER 4-1-03 DATE 11/15/68 BUDGET $81,000

- TASK DESCRIPTION -

1. After completion, the well will be shut in until a "Static" pressure is obtained. At this time, an intermediate length flow test will be made. The results of this test will be evaluated and reviewed with the BuMines. (The tapes will be processed and an independent analysis of results will be made.)

2. If the data from the initial test warrants it, a series of short-term tests and a long-term test will be run. The test results will be evaluated in conjunction with BuMines. (The tape will be processed and an independent evaluation of results will be made.)

3. The first draft of the reservoir analysis report will be written and reviewed with BuMines. (A computer processed reservoir analysis model will run to obtain a preliminary estimate of post-shot flow behavior.)

4. The final pre-shot reservoir evaluation report will be written and reviewed.

PROJECT Rulison

TASK Weather Data Acquisition SCHEDULE Continuing

TASK NUMBER 4-1-04 DATE 11/15/68 BUDGET $13,000

- TASK DESCRIPTION -

Provide, operate, and maintain facilities for acquisition of climatological weather data at four locations in Rulison area.

PROJECT Rulison

TASK Initial Safety Studies SCHEDULE Complete by D-Day

TASK NUMBER 4-1-05 DATE 11/15/68 BUDGET $38,000

- TASK DESCRIPTION -

Provide professional and supporting services for preliminary documentation and evaluation in the areas of:

1. Area Survey - to identify location and number of residents, residences, livestock and dairies.

2. Bioenvironmental Survey - to evaluate possible effects of the explosion.

3. Geology and Geophysics for documenting geology, evaluating containment and prediction of ground motions.

4. Hydrology - for evaluation of hazards of contamination of aquifers.

5. Structural Response - for evaluation of seismically susceptible structures and prediction of response with preliminary damage estimate.

PROJECT Rulison

TASK Site Acceptability Report SCHEDULE Complete January 15, 1969

TASK NUMBER 4-1-06 DATE 11/18/68 BUDGET $15,000

- TASK DESCRIPTION -

Write and issue Site Acceptability Report.

PROJECT Rulison

TASK Drill and Check R-E SCHEDULE Completed January 30, 1969

TASK NUMBER 4-2-01 DATE 11/15/68 BUDGET $644,000

- TASK DESCRIPTION -

Drill and checking R-E. This includes:

1. Drilling and associated materials
2. Coring
3. Logging, wireline services
4. Casing
5. Cementing (including materials)
6. Drying hole and subsequent checks
7. 80,000 pound weight check

PROJECT Rulison

TASK Power SCHEDULE Continuing

TASK NUMBER 4-2-02 DATE 11/19/68 BUDGET $40,000

- TASK DESCRIPTION -

Single Phase 120 V commercial power will be furnished to the site for use during Phase II (User Occupancy) and Phase III as required.

An emergency 20 kW generator will be hooked up to the security van, security lights and the wellhead shack.

PROJECT Rulison

TASK Power Distribution SCHEDULE Completed D - 8 wks.

TASK NUMBER 4-2-03 DATE 11/18/68 BUDGET $6,000

- TASK DESCRIPTION -

Construct, assemble and install power distribution backboards. Hook-up all the users in the activity areas to the backboards. Assume that all trailers have switch or breaker boxes.

Bury cables where exposed to damage.

PROJECT Rulison

TASK Site Illumination SCHEDULE D - 8 wks to D-Day

TASK NUMBER 4-2-04 DATE 11/18/68 BUDGET $8,000

- TASK DESCRIPTION -

Illumination of the site involves two areas, the CP and SGZ.

500 watt quartz iodide lamps will be used, mounted on 40 foot class 3 poles. Each pole will have a fused "on-off" switch at the base for turning on and off the lights.

There will be 4 poles at the CP and 4 at SGZ.

PROJECT Rulison

TASK Explosive Emplacement & Stemming SCHEDULE D - 21 days to D - 1 day

TASK NUMBER 4-2-05 DATE 11-27-68 BUDGET $116,000

TASK DESCRIPTION

This includes all labor, material and equipment necessary for device emplacement and stemming of Hole R-E and stemming of Hole R-EX. Does not include cost of device or laboratory personnel.

PROJECT Rulison

TASK On-Site Telephone Communication SCHEDULE D - 8 wks to D-Day

TASK NUMBER 4-2-06 DATE 11/18/68 BUDGET $3,000

- TASK DESCRIPTION -

This task involves the installation and maintenance of the "on-site" telephone net. It is made up of field phones and field wire.

It will be composed of 22 instruments and will have 3 "long lines" linking SGZ with the CP.

PROJECT Rulison

TASK Site Telephone Communications SCHEDULE D - 6 wks to D + 1 wk

TASK NUMBER 4-2-07 DATE 11-26-68 BUDGET $15,000

TASK DESCRIPTION

Four systems of telephone communications are available:

System 1. One pair hardwire from Mountain States Telephone at Grand Valley to SGZ. Instruments may be added at CP or GZ.

System 2. Radio telephone (one channel) from Mountain States Telephone at Grand Junction to the CP.

System 3. Radio telephone (two channel) from Westcol Radio Dispatch at Grand Junction to SGZ. Interconnection to Mountain States Telephone service is at Grand Junction.

System 4. Field telephone system from CP to SGZ.

PROJECT Rulison

TASK Low Band Radio Net SCHEDULE D - 6 wks to D + 1 wk

TASK NUMBER 4-2-08 DATE 11-26-68 BUDGET $23,000

TASK DESCRIPTION

1. Install mobile radio in vehicles and aircraft.

2. Install fixed base stations with remotes and provide speaker mikes in trailers at SGZ and CP, etc.

3. Install transmitters (repeaters) and erect towers with antenna. Provide weather protection for equipment.

4. Obtain right-of-way and build road to repeater site.

PROJECT Rulison

TASK Public Health and Safety SCHEDULE D - 5 wks to D + 1 wk

TASK NUMBER 4-2-09 DATE 11/15/68 BUDGET $61,000

- TASK DESCRIPTION -

Provide technical, professional and supporting services to furnish:

1. Documentation by dosimetric methods of radiation dose, if any, experienced at selected off-site locations. Assumed is use of 200 thermo-luminescent detectors with 10 controls at about 85 locations.

2. Documentation by fixed and mobile air sampler methods of airborne radioactivity, if any, released at the time of the explosion. Assumed is use of 10 fixed and 4 mobile air samplers.

3. Documentation by sampling and analysis methods of the quality of ground and surface water sources before and after the explosion. It is assumed that 130 water samples are taken and analyzed.

4. Documentation by sampling and analysis methods of the quality of milk and livestock feed sources before and after the explosion. It is assumed that 50 each of milk and vegetation samples are taken and analyzed.

5. Field monitoring for evacuation of people and for monitoring for radioactivity, if any, released.

6. Aerial sampling and monitoring capability on stand-by, assumed to be at Grand Junction.

7. Medical and veterinary services as required.

PROJECT Rulison

TASK Industrial Safety SCHEDULE Continuing

TASK NUMBER 4-2-10 DATE 11-19-68 BUDGET $12,000

- TASK DESCRIPTION -

1. A first aid man with an ambulance and a first aid trailer will be located at SGZ until D-Day, at which time the activity will be moved to the CP area.

2. Seven chemical toilets will be located at three locations. Three at the observer area, two at the CP and two at SGZ. The toilets will be serviced.

3. Carbon Dioxide Fire Extinguishers will be supplied to each non-user furnished trailer. The Helicopter Pads will also be equipped with CO_2 extinguishers.

4. Contract with a medical doctor to be on stand-by at a nearby city.

PROJECT Rulison

TASK Aircraft Support SCHEDULE D - 2 days to D-Day

TASK NUMBER 4-2-11 DATE 11-18-68 BUDGET $6,000

TASK DESCRIPTION

The following aircraft will be supplied:

1. Helicopter for area familiarization and security sweeps on D-1 and D-Day.

2. Helicopter for SGZ photograph and surveillance at shot time.

3. Kingair Turboprop for the USPHS, on stand-by at nearby air field and D-Day mission for sampling of vented gases, if any.

4. NATS Martin 404 on stand-by in Las Vegas.

The helicopters will be rented locally and will work out of the observer area by the highway.

PROJECT Rulison

TASK Ground Motion and Structural Response SCHEDULE D - 1 mth to D + 2 mths

TASK NUMBER 4-2-12 DATE 11/18/68 BUDGET $182,000

- TASK DESCRIPTION -

Provide technical, professional and supporting services:

1. To evaluate probability of containment of the explosion by analysis of geologic conditions and casing, cementing and stemming plans.

2. To prepare predictions of ground motion amplitudes as a function of distance from SGZ for various surface conditions.

3. To identify the location and character of structures subject to significant ground motion and document the condition before and after the explosion of about 300 selected structures. Provide 12 structural response observers to make prompt post-explosion examination of structures affected by ground motion.

4. To install, calibrate, maintain and operate seismometers at about 23 locations.

5. To process and analyze ground motion data and to correlate it with complaints of damage attributed to ground motion.

6. To evaluate the condition of mines, wells and pipelines to document condition and to take preventive measures. To assure safety of operators and public.

PROJECT Rulison

TASK Geologic, Geophysical & Hydrologic Studies SCHEDULE D - 6 wks to D + 4 wks

TASK NUMBER 4-2-13 DATE 11/15/68 BUDGET $10,000

- TASK DESCRIPTION -

Provide professional services as follows:

1. To document geologic and hydrologic conditions as required to evaluate the safety of the experiment from standpoints of containment, possible contamination of aquifers.

2. To evaluate core and logging data as related to prediction of explosion effects.

3. To document pre-explosion condition of selected ground and surface water sources in the area and to evaluate possible complaints of damage to them attributed to ground motion.

PROJECT Rulison

TASK Meteorological Support for Radiological Safety SCHEDULE D - 4 wks to D + 1 wk

TASK NUMBER 4-2-14 DATE 11/15/68 BUDGET $60,000

- TASK DESCRIPTION -

Technical and professional services as follows:

1. Installation, operation and maintenance of powered wind-sensors at four locations for telemetary of data to CP.

2. Installation, operation and maintenance of pibal and GMD sounding equipment.

3. Preparation of periodic forecasts of weather conditions and predictions of fall-out radiation dose patterns in the remote contingency of release of radioactivity to the atmosphere.

PROJECT Rulison

TASK Security SCHEDULE D - 3-1/2 wks to D + 1 day

TASK NUMBER 4-2-15 DATE 11/18/68 BUDGET $32,000

- TASK DESCRIPTION -

Provide classified security coverage at SGZ wellhead shack during period nuclear device is on-site. Security coverage will also be available to cover A & F trailer at shot time.

Assumption:

This sub-coverage will be with an AEC contractor which is self supporting.

PROJECT Rulison

TASK Joint Office of Information & Observer Effort SCHEDULE Jan 69 to completion

TASK NUMBER 4-2-16 DATE 11-18-68 BUDGET $23,000

- TASK DESCRIPTION -

This task includes all necessary support to JOI plus the official visitors during shot time. The observers will be an involved effort with briefings, travel arrangements, luncheons, hand-out type brochures, tours of the area. Travel by bus to and from the observer area on event day, meals at the site and so on.

PROJECT Rulison

TASK Drill R-PS-1 SCHEDULE D + 6 mos to D + 8 mos

TASK NUMBER 4-3-01 DATE 11/19/68 BUDGET $175,000

- TASK DESCRIPTION -

This involves the drillback into the cavity and the necessary preparation for test and evaluation. The budget assumes some difficulties and the "worse case" situation is figured into contingencies.

PROJECT Rulison

TASK R-PS-1 Testing SCHEDULE D + 8 mos to completion

TASK NUMBER 4-3-02 DATE 11/19/68 BUDGET $100,000

- TASK DESCRIPTION -

Test and evaluate R-PS-1.

PROJECT Rulison

TASK Gas Flaring System, Phase III SCHEDULE D + 6 mos to completion

TASK NUMBER 4-3-03 DATE 11/15/68 BUDGET $15,000

- TASK DESCRIPTION -

The gas from R-E is to be flared and if the radioactivity dictates the need for increased dilution, the flared gas is to be ignited. Considering the BTU involved with the burning gas, the radiant heat necessitates that the flare stack be approximately 800 ft from the work area.

The system will consist of 3-5/8 in pipe going from the wellhead to a 10 ft by 15 ft by 6 ft water tank (gas filter), and then to the flare stack. Propane tanks and a line to the flare stack will provide the ignition system.

PROJECT Rulison

TASK Project Management SCHEDULE Continuous

TASK NUMBER 4-4-01 DATE 11/15/68 BUDGET $186,000

- TASK DESCRIPTION -

Includes all supervision and coordination effort both on and off-site plus clerical support. It also involves the drafting circulation, finalization, printing and issuance of the final Rulison Report.

PROJECT Rulison

TASK General Construction SCHEDULE Continuing

TASK NUMBER 4-4-02 DATE 11/15/68 BUDGET $76,000

- TASK DESCRIPTION -

All construction specified for the project exclusive of drilling, explosive emplacement and power distribution. It includes items such as:

1. Scientific cabling (excluding downhole).
2. Earth work at CP and SGZ.
3. Wellhead shack with strengthened floor and tie down.
4. Fire breaks.
5. Procure and install head frame and associated equipment for R-E.
6. Post shot installation of 6 ft chain link fence at SGZ. (1000 ft)
7. Structural bracing for ground motion.
8. Install 9 RAMS units on posts.
9. Decontamination pad and evaporation pit.

PROJECT Rulison

TASK General Support SCHEDULE Continuing

TASK NUMBER 4-4-03 DATE 11/19/68 BUDGET $220,000

- TASK DESCRIPTION -

This function includes:

1. Road maintenance
2. Labor support to participating organizations
3. Trailer costs and support
4. Other office space
5. Rent of office equipment
6. Equipment support to participating organization
7. Drinking water, travel cans, etc.
8. A/C equipment (as specified) and maintenance
9. Rope fence at SGZ
10. Major site rollup - Phase II
11. Petroleum, oil, and lubricants
12. Final rollup - Phase III

PROJECT Rulison

TASK Surface Transportation SCHEDULE Continuing

TASK NUMBER 4-4-04 DATE 11/18/68 BUDGET $31,000

TASK DESCRIPTION

The following vehicles are to be furnished to the project, and it is assumed that GSA rented vehicles will be available.

	Phase II	Phase III
Sedans	72 each	7
Pickup truck, 1/2 ton 4 x 2	31 each	5
Pickup truck, 1/2 ton 4 x 4	7 each	1
Station Wagon	1 each	
Carryall 4 x 2	5 each	
Carryall 4 x 4	3 each	
Metro Type Van	2 each	

PROJECT Rulison

TASK On-Site Radiological Safety SCHEDULE Continuing

TASK NUMBER 4-4-05 DATE 11/15/68 BUDGET $80,000

- TASK DESCRIPTION -

Provide technical and professional services and related materials and equipment for:

1. Installation and operation of 9 remote area monitoring system (RAMS) units and air samplers.

2. Installation and operation of Access Control and Radiological Measurements trailer equipment and supplies, including personnel dosimetry, clothing exchange, decontamination of clothing, and analysis of radioactive samples.

3. Radioactivity monitoring of area, drilling returns and blooie line and flaring stack effluent.

4. Decontamination of any contaminated equipment.

5. Disposition of contaminated drilling returns and equipment which cannot be decontaminated to acceptable levels.

IX.

ABBREVIATIONS

AEC	Atomic Energy Commission
AOC	Air Operations Center
A & F	Arming and Firing
ARL/LV	Air Resources Lab/Las Vegas
bbl	Barrel
BHC	Bore hole compensated
BHP	Bottom hole pressure
BHST	Bottom hole stabilized temperature
BuMines	U. S. Bureau of Mines
CER	CER Geonuclear Corporation
cm	Centimeters
cp	Centipoise
CP	Control point
D	Day of shot
DONO	Director of Nuclear Operations
DST	Drill stem test
ERC	Environmental Research Corporation
ESSA	Environmental Science Services Administration
FAA	Federal Aviation Administration

ABBREVIATIONS

FSL	From the South Line
FWL	From the West Line
g	Acceleration due to gravity 32. ft/sec/sec
gm/cc	Grams per cubic centimeter
GMD	Ground Meteorological Device
H	Depth of shot point subsurface
ID	Inside diameter
IES	Induction electrical survey log, consisting of induction, short normal, and self potential curves
JOI	Joint Office of Information
kh	Flow capacity, average permeability (millidarcys) milti-plied by feet of net pay
kt	Kiloton
kw	Kilowatt
LASL	Los Alamos Scientific Laboratory
LRL	Lawrence Radiation Laboratory
md	Millidarcy
MPC	Maximum permissible concentration
NTS	Nevada Test Site
NVOO	Nevada Operations Office
OD	Outside diameter
PM	Program Manager

ABBREVIATIONS

psi	Pounds per square inch
RAMS	Remote Area Monitoring Station
r_c	Cavity radius
R-E	Rulison Emplacement Well. Well in which nuclear explosive will be lowered, stemmed and detonated
REECo	Reynolds Electrical Engineering Company, Inc.
R-EX	Rulison exploratory well
R-PS-1	Post-shot re-entry well number 1
R-PS-2	Post-shot re-entry well number 2
RTTS	Halliburton's retrievable test-treat-squeeze tool
RVT	Halliburton's retrievable valve tester
scf	Standard cubic feet
SGZ	Surface Ground Zero
SP	Self potential log
TD	Total depth of well
TWX	Teletype service
USGS	United States Geological Survey
USPHS	United States Public Health Service
VDL	Variable density sonic character log
W	Explosive yield, kilotons
WP	Working point - location of nuclear explosive

ABBREVIATIONS

3-D	Type of sonic character log
^{o}F	Degrees Fahrenheit
$\sim$	Approximately
$<$	Less than

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